THE PLANT DISEASE REPORTER

Issued By

CROPS RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

Volume 44 Number 4

April 15, 1960

The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Crops Research Division serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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Paul R. Miller

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THE PLANT DISEASE REPORTER

Crops Research Division
Volume 44

Plant Industry Station, Beltsville, Maryland
April 15, 1960
Number 4

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WEATHER MAP ANALYSIS -- AN AID IN FORECASTING POTATO LATE BLIGHT[1]

Jack R. Wallin[2] and John A. Riley, Jr.[3]

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Summary

Late blight severity values estimated from microclimatic data were plotted on: Daily, 5-day, and 30-day weather maps to determine the efficiency of such maps in identifying those temperatures and relative humidities in potato and tomato foliage that favor the development of Phytophthora infestans, the potato late blight fungus.

The typical model on a daily surface weather map indicative of late blight conditions in crop cover was a nearly stationary east to west front just south of the observation area with a weak migratory low-pressure system along the front. The wind flow on the ground was from east to west, north of the front.

The identification of favorable blight weather was made from 5-day mean surface and upper air maps. Southeasterly surface wind flow and southwesterly flow at 10,000 feet indicated favorable weather. West to northwest wind flow at the surface and at 10,000 feet indicated unfavorable blight weather. A graph showing the relation of the two wind directions to the degree of blight favorable humidity was presented and can be used with regular prognostic maps issued by the Weather Bureau to give a 5-day outlook for blight favorable weather.

Thirty-day mean surface weather maps were related to blight intensity. Pressure was higher to the north and west of the target area during blight than during no-blight years. Therefore, a 30-day forecast calling for stronger than normal easterly winds at the surface would be a warning of blight favorable weather.

INTRODUCTION

The primary influence of weather and its variation on the late blight fungus, Phytophthora infestans (Mont.) D By., has been recognized for many years. Laboratory experiments (6, 7) under controlled conditions and field experiments relating the growth and development of the fungus to temperature and relative humidity data obtained by hygrothermographs in louvered shelters located 12 inches above the soil in potato or tomato cover (10, 12, 16) formed the basis of a field forecasting service of this disease for the North Central States (11, 13, 14) begun by the Department of Agriculture in 1948. Others have found that temperature and relative humidity data obtained in potato cover correlated with those weather conditions critical to the fungus (9).

The identification and forecast of late blight weather from synoptic weather maps was initiated by Bourke in Ireland. He used the technique in the British Isles and parts of Europe (1, 2, 3, 4). Later, he used a similar method in Chile (5).

Bourke defined "a blight-weather spell" as a 12-hour period with temperature not below 10° C and relative humidity not below 90 percent. The 12-hour period sufficed only if conditions were such that the foliage was likely to remain wet for a subsequent period of at least 4 hours; if not, the minimum period of 90 percent humidity was 16 hours.

Bourke's method suggested two aids in improving the forecasting method presently employed in the North Central States. First, it offered a solution to the problem of covering an area the size of the North Central States, over 500,000 square miles. Weather patterns, as shown on weather maps, are large scale phenomena and cover many thousand square miles rather than individual locations. Second, it would eliminate the delay from observation to fore-

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[1] Journal Paper No. J-3634 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project 1163. Report of a cooperative investigation of the Iowa Agricultural Experiment Station and the Crops Research Division, Agricultural Research Service, United States Department of Agriculture and the Weather Bureau, United States Department of Commerce. Grateful acknowledgment is accorded C. E. Lamoureux, Meteorologist in Charge of the Airport Station, Weather Bureau, Des Moines, Iowa, for his support in the investigation through the use of his facilities and personnel.

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cast necessitated by mailing weekly weather reports. Weather maps are current, thus they minimize delays in weather reporting. Furthermore, the prediction of weather patterns projects the pathologist's working information into the future.

The procedure employed in the North Central States was based on Bourke's technique of weather map analysis with two major modifications: 1) the definition of a blight period was different, and 2) the scope of map analysis was expanded in time to include mean charts of 5-day and 30-day intervals and in space to include upper air maps. Preliminary studies indicated the effectiveness of such analyses (8, 15). Weather map analysis is presented here as an aid to the present techniques employed by the pathologist, not as a substitute. Probably such analyses may provide a valuable tool for identifying and forecasting potato late blight weather and for predicting other diseases.

RELATION OF DAILY SURFACE WEATHER MAPS TO SURFACE BLIGHT CRITERIA

The purpose of the weather map analysis was to determine if such maps could be used to plot certain micro-climatic temperature--relative humidity criteria for late blight development. These criteria, shown in Table 1, were developed in the North Central States (10, 16) and are presently employed in late blight forecasting in the North Central States (11). The criteria have been used successfully in late blight forecasting during the past 3 years.

Table 1. The relation of the hours' duration of given average temperatures coincident with relative humidities $\geq$ 90 percent to the estimated severity of secondary infection of *Phytophthora infestans*.

Temperature range °F	Hours expected to produce estimated infection severity[a] 1	2	3	4
45-53	16-18	19-21	22-24	+24
54-59	13-15	16-18	19-21	22+
60-80	10-12	13-15	16-18	19+

[a]1 = 0 to trace secondary infection; 2 = trace to slight; 3 = slight to moderate; 4 = moderate to heavy.

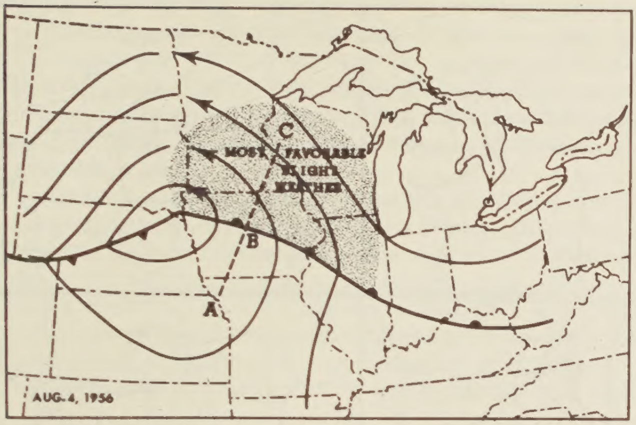
The daily temperature and relative humidity data from hygrothermographs at 21 reporting stations located in tomato or potato fields were transformed into late blight severity values as defined in Table 1. The resulting values for each station were entered on the daily 6AM CST surface weather maps. Certain weather patterns were noted to occur frequently with certain severity values.

Figure 1 shows the surface circulation for the morning of August 4, 1956 and is regarded as a rather typical model that is associated with the moderate-severe blight severity index[4]. Blight severity values of 4 occurred to the north of the warm front in Minnesota and Wisconsin, while south of the front values were lower. The east to west front, shown in Figure 1 in northern Iowa and Illinois, is the map feature most commonly associated with blight severity index values of 3 and 4. The wind flow on the ground north of the front is from east to west as shown by the arrows. However, on a vertical scale, winds shifted to southerly about 3 to 6000 feet above ground. At this height, warm, moist southerly air was forced over the warm front and the resulting cooling of the air caused condensation and eventual precipitation as illustrated by Figure 2. The slow but steady rise of air over the warm front produced a slow and steady type of precipitation, in some cases light rain, light drizzle or only cloudy humid conditions -- all of which promote the development of the late blight fungus.

Western Nebraska was an exception to the model. As the terrain slopes upward from east to west, any easterly flow that continued long enough and had some moisture in the lower levels resulted in very humid conditions on the ground. A warm front immediately south of this area was not necessary to produce blight severity values of 3 and 4 although it usually accompanied the easterly flow.

If blight severity values of 1 or 2 occurred on only 1 day and was followed by sunny dry weather, the control problem for the grower would be very much simplified. The long periods

[4]Hereafter, a severity index of 3 or 4 for a 24-hour period will be referred to as most favorable for secondary infection of *Phytophthora infestans*.



Legend;
indicates direction of wind flow along the isobars, counter-clockwise around a low-pressure center.
sea-level barometric pressure isobars.
cold front, warm front
A--B--C imaginary cross section line through low-pressure system.

FIGURE 1. Map depicting the low-pressure system and resulting air circulation pattern providing the most favorable blight weather for a given area.

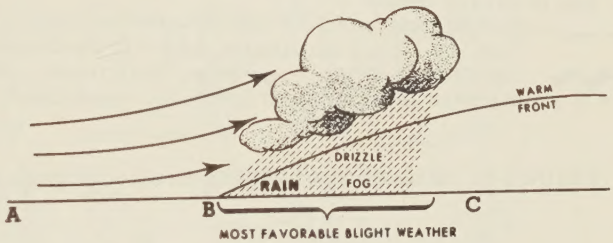


FIGURE 2. Cross-section model through the low-pressure system of Figure 1 along the line ABC illustrating the moisture conditions prevailing ahead of the warm front.

of favorable temperatures and relative humidities, however, make adequate control difficult. Such a period is shown in Figure 3, where blight severity values of 3 to 4 continued for several days in parts of Minnesota, Wisconsin and Iowa. In general, the high severity values appear north of the warm front with lower values south of the front. The low-pressure system often found on the western end of the warm front, or the point where the warm front turns into a cold front, was usually the western terminus of the high severity values.

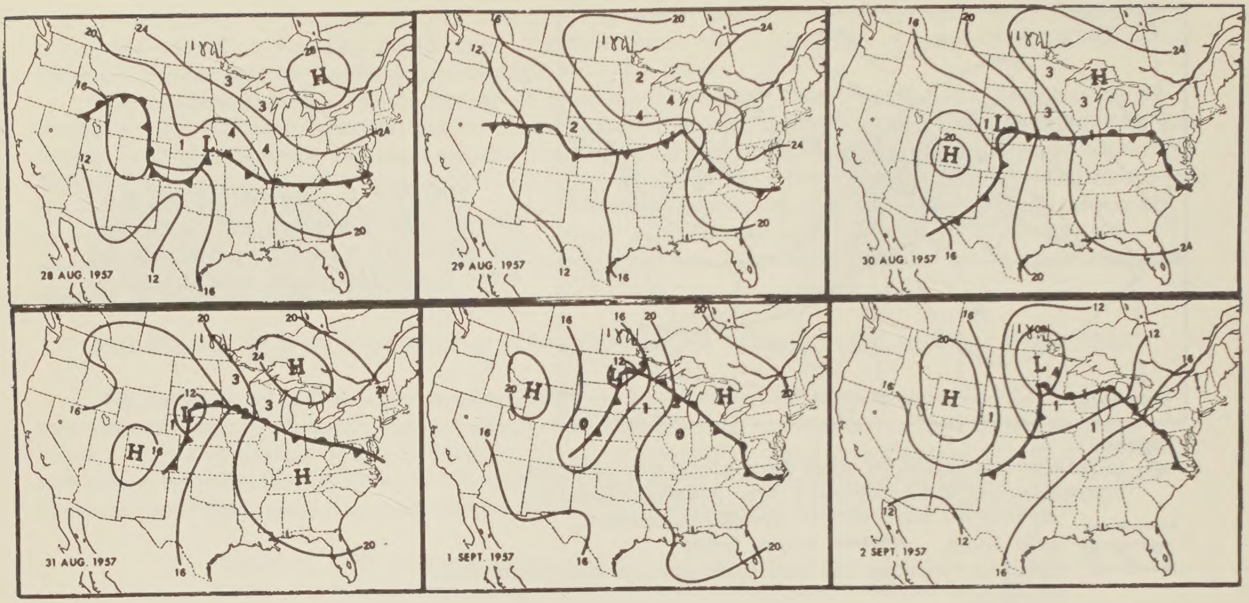
The map series depicted in Figure 3 occurred from August 28 through September 2, 1957. Within 10 days following this last map, a late blight outbreak occurred at 55 percent of the stations in Iowa, Minnesota and Wisconsin. Active control measures in effect before the series and just following the series probably prevented a greater number of outbreaks. A similar series occurred near the same date in 1956 and in 1958.

The typical "series model" then was the nearly stationary east to west front just south of the target area with a weak migratory low-pressure system on the front. This stagnant period of favorable weather labeled the "series model" is probably the most significant period during the blight year. Accurate forecast of such periods, or the quick recognition of their initiation, may allow grower's to initiate adequate control measures.

RELATION OF 5-DAY WEATHER MAPS TO SURFACE BLIGHT CRITERIA

The 5-day period was chosen for analysis because the Weather Bureau issues routine weather forecasts for that period which might be used for late blight warnings.

The preparation of a mean 5-day prognostic map is a preliminary step in making the 5-day forecast that is released to the public. The maps show the expected pressure pattern on the surface and the height contour pattern at 700 millibars (averages about 10,000 feet above sea level). The regular 5-day forecast separates the mean map into daily components from which



Legend:
H, high pressure center
L, low pressure center
, isobars expressed as abbreviated millibars. The first two digits were omitted, i.e. 12 = 1012 millibars, 16 = 1016 millibars, etc.
, stationary front, , cold front, warm front
0 - 4 , indicates least to most favorable conditions.

FIGURE 3. Widespread blight favorable weather pattern of 1957 in the North Central States.

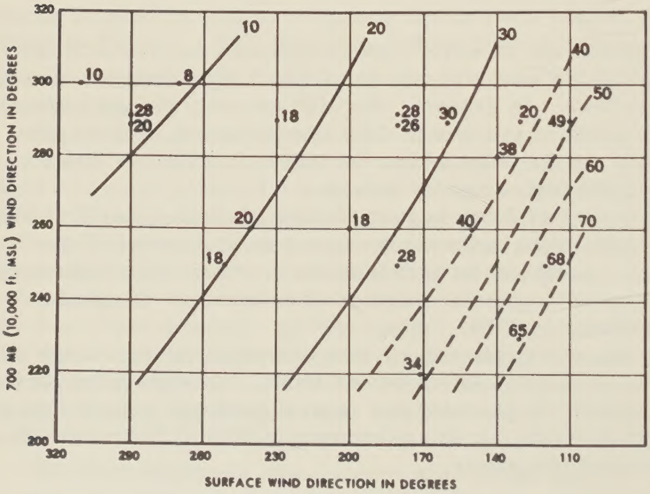


FIGURE 4. The relation of wind direction at the surface and at 700 millibars (10,000 feet) to the percentage of the possible maximum weighted relative humidity value (15) for 5 days during 19 five-day periods at micro-weather stations in the northern Iowa and southern Minnesota. 1956-57. (Method of weighting relative humidity values shown in the text).

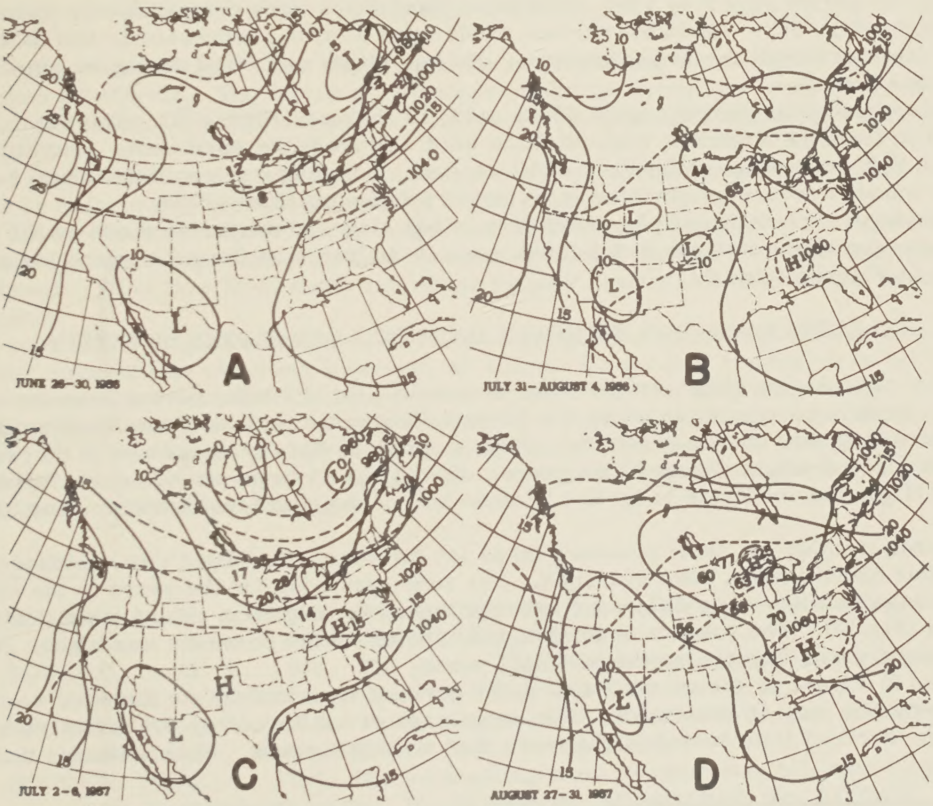
the temperature and precipitation forecast is determined. In the 5-day outlook for blight weather, these latter steps are omitted and a forecast of favorable blight humidities is made directly from the original mean 5-day prognostic maps.

To ease computations different criteria were used to classify blight favorable humidity. The periods of relative humidity ≥ 90 percent were weighted for each of the weather blight stations located in crop cover. A 10-hour period of relative humidity ≥ 90 percent was weighted 1; 15-19 hours 2; and 20 or more hours 3. The period was used if its temperature mean met the

minimum temperature requirements, that is, 10-hour periods whose mean temperatures were 60° F or more and 13-hour periods of temperature mean 54° or more, and 16-hour periods of mean temperature 45° or more. For a 5-day period the maximum weighted value for any one station would be 15, or five times the daily maximum weighted value of 3. The weighted values for all stations in each geographical location were averaged and a percentage of the maximum was computed. These final values correspond to a percentage of the time that the humidity was 90 percent or more.

Figure 4 shows the relation of the humidity function to the direction of the wind at the ground and at 10,000 feet above sea level. High values of humidity are found in the lower right-hand side of the graph. This indicates that southeast winds near the ground and southwest winds at 10,000 feet are associated with long periods of high humidity in crop cover on the ground. Low values of relative humidity are grouped in the upper left-hand part of the graph. This indicates that unfavorable humidity conditions for the blight fungus or humidities 90 percent less than 10 hours, occur with west to northwest surface winds and at 10,000 feet.

Representative 5-day mean weather patterns of 1956 and 1957 were plotted in Figure 5.



Legend:

isobars expressed as abbreviated millibars, i.e. 10 = 1010 millibars, 15 = 1015 millibars, etc.

isobars at 700 mb. surface expressed as abbreviated elevation, i.e. 1,000 = 10,000 ft., 1020 = 10,200 ft., etc.

FIGURE 5. Five-day mean pressure maps depicting circulation patterns for 1956 and 1957, and the percentage of time (heavy-lined numerals) that relative humidities were $\geq$ 90 percent. A -- A five-day period during which the relative humidities were $\geq$ 90 percent a low percentage of the time. B -- A 1956 five-day period during which the relative humidities were $\geq$ 90 percent a greater percentage of the time. C -- A 1957 five-day period during which relative humidities were $\geq$ 90 percent a low percentage of the time. D -- A 1957 five-day period during which the relative humidities were $\geq$ 90 percent most of the time.

Figure 5A depicts the period June 26-30, 1956, a period when relative humidities were $\geq$ 90 percent in potato cover a low percentage of the time. Note the west to northwest wind flow at the surface illustrated by the solid lines and the westerly wind flow aloft at 10,000 feet depicted by the dotted lines. Only 8 and 12 percent of the 5-day period had relative humidities of 90 percent or more recorded in the northern Iowa-southern Minnesota sector and the Red River Valley, respectively. No late blight was reported from any station immediately following this period.

In contrast, during the period July 31-August 4, 1956, the winds were southeasterly at the surface and southwesterly at 10,000 feet (Fig. 5B). During this period, relative humidities in the potato foliage were 90 percent or more 44 percent of the time in the Red River Valley and 65 percent of the time in the northern Iowa-southern Minnesota sector. Late blight was found in the Valley, Iowa, Minnesota and Wisconsin after this period. The above situation illustrates a period during which the late blight pathogen will develop and spread in the field and not necessarily a period preceding the discovery of symptoms of the disease, although this happened in this case. Several such periods may occur before late blight symptoms become apparent in the field, depending upon the stage of development of the host plants.

During the period July 2-6, 1957 the relative humidities were comparatively unfavorable for late blight (Fig. 5C). Again the surface winds were west to northwesterly and those aloft at 10,000 feet were from the same direction. No late blight was found during or immediately following this period.

The most favorable period August 27-31, 1957 is shown in Figure 5D. The winds at the surface were from the southeast while the flow aloft was from the southwest. Humidities were favorable a high percentage of the time at all sectors, including western Nebraska. Late blight was found in severe proportions in all sectors following this period.

The physical explanation of why southwest winds aloft and southeast winds on the ground are favorable for blight on these 5-day mean maps is the same as the explanation for a single day shown in Figures 1 and 2.

RELATION OF 30-DAY WEATHER MAPS TO LATE BLIGHT SEVERITY

General outlooks for blight weather may be possible for a 30-day period because regular prognostic 30-day charts are issued by the Extended Forecast Section of the Weather Bureau.

Northern Iowa was chosen to test the efficacy of the 30-day period because of the relatively equal occurrence of blight and no-blight years. During the 11-year period from 1947 through 1957, late blight was moderate to severe in about half of the years and trace or none in the other half.

The mean monthly sea level pressure maps for the years that blight was reported in the trace or none classification were averaged. The same was done for the years in the moderate to severe classification. The difference between these two long term means were computed and plotted (Fig. 6). The positive anomalies indicate where the pressure was higher during the reported blight years than during the no-blight years.

As seen in Figure 6, the anomaly was to the north of Iowa in July, to the northwest in August, and to the west in September. For an average of the 3 months, the pressure was higher to the north of Iowa during blight years than no-blight years. This indicates that, in

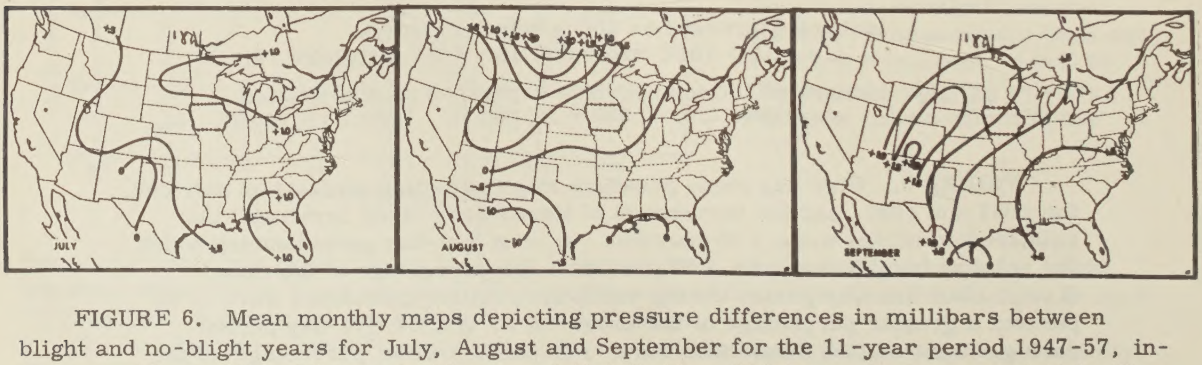


FIGURE 6. Mean monthly maps depicting pressure differences in millibars between blight and no-blight years for July, August and September for the 11-year period 1947-57, inclusive. The positive values = incidence and distribution of higher pressure associated with the blight years.

general, the surface winds in Iowa were predominantly more easterly during the blight years than during the no-blight years, which conforms to the patterns shown on the daily and 5-day mean maps.

The westerly migration of the positive anomaly during the growing season could be fictitious because only 11 years of data were available. However, a possible explanation might be as follows. Early in the season, during July, the positive anomaly was to the north or northeast of the target area which indicates a stronger than normal southeasterly flow over Iowa. This is usually accompanied by more than normal thundershower activity, the main cause of favorable periods during that month. In August the positive anomaly was northwest, which results in above normal east to northeasterly surface flow. The same situation was true in September, only the positive anomaly was farther west indicating that favorable blight weather was associated with stronger than normal east and northeasterly flow. These conditions accompany stronger and more frequent low-pressure systems moving out of the southeast and gave Iowa higher than normal humidity and precipitation.

CONCLUSIONS

The daily weather maps were fairly accurate in identifying the moderate to severe secondary infection conditions. The minimum secondary infection conditions were not so easily identified from the maps. The 1 and 2 severity values occurred in all sections of a given low-pressure system.

The 5-day weather maps were effective in identifying surface relative humidity conditions favorable or unfavorable to the development of late blight.

The 30-day weather maps for July, August and September revealed that, in general, during the blight years the surface wind flow was stronger than normal from the southeast, east and northeast. Wind flow from these directions usually results in above normal humidities and precipitation.

The forecast of blight favorable weather from prognostic weather maps was less specific as the time element was extended; however, an outlook for general conditions as far as a month in advance was possible utilizing regular Weather Bureau prognostic maps.

Weather map analysis provided an additional tool to the crop disease forecaster. In the future the use of weather map analyses may be applicable to other crop pathogens such as the cereal rusts which will develop into epiphytotic proportions under intermittent periods of continuous high humidity and wet foliage.

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REEVALUATION IN MAINE OF THREE METHODS PROPOSED FOR FORECASTING LATE BLIGHT OF POTATO

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Abstract

To assist potato growers with the timing of their fungicide applications for the control of late blight (due to Phytophthora infestans Mont. D By), three methods of forecasting the disease were reevaluated in Maine. In 1959 the incidence of late blight might have been accurately forecast. The "moving-graph" method, based on rainfall and temperature data, would have been satisfactory for this purpose. The other two methods were based on relative humidity and temperature data. As interpreted, the 90 percent relative humidity method would have been somewhat less satisfactory than the moving-graph method; the 75 percent relative humidity method (Beaumont periods) would have been inaccurate.

METHODS

A warning service was initiated in Aroostook County, Maine in 1931 (1) to assist the growers with the timing of protective sprays for the control of late blight of potato. The growers were notified when the disease was first reported; that is, already present. To extend this service, the development of methods for forecasting the appearance and spread of late blight has been studied in recent years. Three methods, evaluated in 1958 and described by Hyre et al. (2), were reevaluated in 1959. Briefly, the methods are as follows:

a. Moving-graph method: Days favorable for blight are calculated from U. S. Weather Bureau rainfall and temperature data by means of "moving-graphs." A "favorable" day occurs when the 5-day mean temperature is less than 78° F, and the 10-day total rainfall is 1.2 inches or more. Initial blight is forecast after 10 consecutive blight-favorable days. The disease is expected 1 or 2 weeks after it is forecast.

b. 90 percent relative humidity method: Blight "severity-values" are calculated from relative humidity and temperature data. In this case the relative humidity must be 90 percent, or more, for 10 to more than 25 hours when the mean temperature range varies from 80° to 45° F. In 1959 the hygrothermograph was located 15 inches above sod cover at Aroostook Farm, Presque Isle, Maine.

c. 70 percent relative humidity method: "Beaumont" periods, occurring after a "zero" date, are used for forecasting blight. A Beaumont period occurs when the relative humidity is 75 percent or more, and the temperature is 50° F or higher, for 48 or more consecutive hours.

The estimated time of first field occurrence of blight was based on reports of the disease received at Aroostook Farm. The percentage of foliage blight at the end of the season was assessed in 176 fields, with the aid of the key devised by Large (3).

RESULTS

In commercial fields in 1959 late blight was slow in becoming established. Although blight was reported on cull piles by June 24, it was mid-August before the first reports of field infection were received from the St. John river valley area, and late August before field infection was reported from the Caribou-Presque Isle area. Once established, however, blight spread rapidly so that over 9 percent foliage infection was recorded on September 11-12 (Table 1). A few fields were severely blighted.

The value of the three methods studied for forecasting blight is indicated in Figure 1. According to Figure 1, blight occurred about when it might have been predicted from "blight favorable periods" as calculated by the moving-graph method. There was one minimum (10 day) or less (9 day) blight-favorable period in June at Caribou and Houlton respectively (a minimum forecast period for initial blight is 10 days), but the potatoes had just emerged by mid-June and blight would hardly have been expected in the field at that time. It did develop,

[1]Respectively, Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Newark, Delaware; late Plant Pathologist; and Assistant Professor of Plant Pathology, Maine Agricultural Experiment Station, Orono, Maine.

Table 1. Amount of potato late blight foliage infection in Aroostook County, Maine on September 11-12, 1959.

Location	Number of fields entered	Percent foliage blight: Range	Percent foliage blight: Average
Presque Isle-Caribou	111	0-75	7.4
Houlton	65	0-95	12.1
Total	176	0-95	9.2

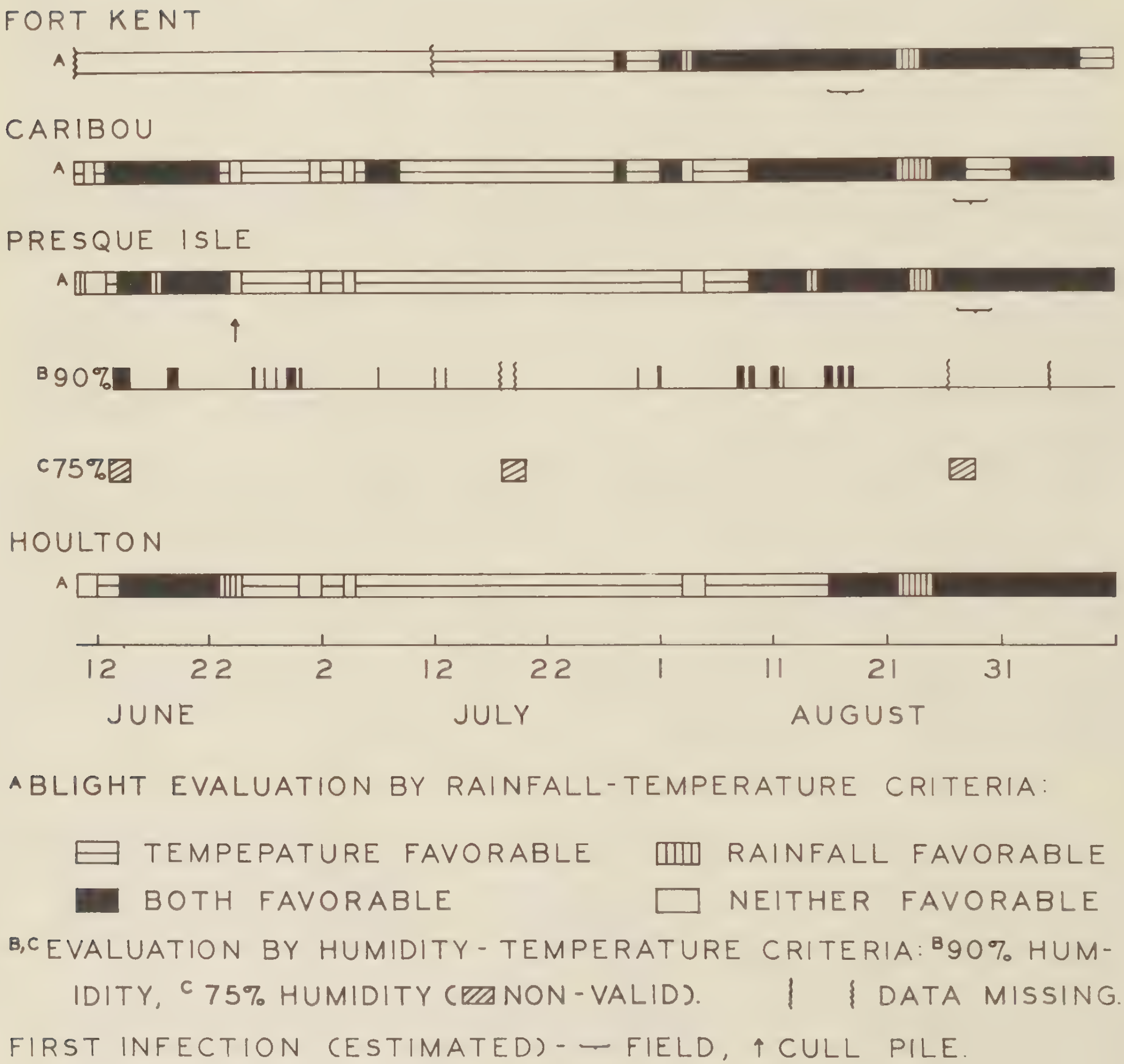

FIGURE 1. Weather data analyzed in relation to the occurrence of late blight of potato in northern Maine in 1959.

however, on the more copious growth on cull piles. No more favorable blight periods of sufficient length to result in a positive blight forecast occurred until early August in the Ft. Kent area and somewhat later in the other areas. As noted in Figure 1, blight developed in the field soon after these favorable periods. The criteria remained favorable for blight and considerable foliage blight was found in September.

The two methods based on relative humidity and temperature were evaluated at only one location, near Presque Isle. By the 90 percent humidity method, blight-severity values were cumulated from the time of emergence of the potatoes. In 1959 this cumulated value, apparently, was about 35 before any significant amount of field infection appeared. In 1958 this figure was somewhat less than 20. In 1959 a flush of infection periods in August corresponded with a marked increase in the amount of blight, although some chart data are missing.

The 75 percent humidity method (Beaumont periods) would have failed to indicate satisfactorily the occurrence of blight. A true Beaumont period didn't occur during the growing season. There were two periods of sufficient length except for 1-hour interruptions (in July and late August), but the first occurred too early for forecasting blight, and the second occurred somewhat late.

DISCUSSION

A number of methods have been proposed for forecasting late blight. This paper reports the 1959 evaluation of three of these. The method that would have been most accurate, and satisfactory, was based on moving-graphs derived from U. S. Weather Bureau rainfall and temperature data. This method has the advantage of relying on data from a number of locations without requiring extra instrumentation.

The method of calculating blight-severity values from relative humidity-temperature data seemed less precise. More experience with, and interpretation of, this method would seem to be necessary for acceptable results. This method, however, appears to be a valuable supplement to the moving-graph method. Finally, the occurrence of Beaumont periods was too inaccurate to be of much value.

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OBSERVATIONS ON WHITE OAK STEM SWELLINGS

Charles D. Huppuch[1]

Foresters have for years observed unusual swellings on white oaks (Quercus alba) throughout the mountains of North Georgia, and in similar areas near Asheville, North Carolina.

This abnormality occurs as a series of swellings, usually at or near the base of the tree, but may extend as high as 25 feet or more up the trunk (Fig. 1). These swellings may completely encompass the main stem or bulge out on one side, causing a lopsided trunk.

General observations indicate that most of these distorted oaks are found on low quality, dry sites at elevations from 2500 to 4000 feet above sea level. The shallow soils are usually rocky, and the sites have been burned or heavily grazed. However, affected trees are occasionally found on moist alluvial soil near streams.

Practically every white oak in stands of one or more acres may exhibit swellings to some extent. In other stands only an occasional tree has a pronounced swelling. Other species of oak in these stands are not affected.

FIGURE 1. These distorted white oaks were found on an eroded farm woodlot in Towns County, Georgia, on a North West aspect and at an elevation of 3200 feet.

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FIGURE 2. A longitudinal section of a swollen white oak trunk. Arrows point to small knots which may be overgrown epicormic branches.

Several trees were cut and sectioned longitudinally. The wood in the swollen areas was sound but contained embedded knots or dormant buds (Fig. 2). The grain of the wood followed the contour of the swelling.

A microscopic inspection of the swellings revealed no mycelium or obvious pathogen in the wood. Perhaps these swelling are only a physiological response of the species to poor environmental conditions. Since the lower trunks of all white oaks contain embedded knots, it is unlikely that the knots alone are the cause of the swellings.

Because this abnormality occurs to only a limited extent, it is of minor importance as a defect in white oak. Rangers on national forest lands consider affected trees sound and usable for crossties and other low grade products, but of little value for cooperage and high grade lumber.

SOUTHEASTERN FOREST EXPERIMENT STATION, FOREST SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE; AND SCHOOL OF FORESTRY, UNIVERSITY OF GEORGIA

THE HOST RANGE OF THE VIRUS OF TWISTED LEAF OF CHERRY[1]

T. B. Lott and F. W. L. Keane[2]

Abstract

Four selections of the virus of twisted leaf of cherry, obtained from naturally infected trees, were inoculated into various stone and pome fruits, mainly in 1952 to 1955. Thirteen varieties of sweet cherry (Prunus avium on P. avium) developed symptoms, and two others became infected without symptom expression. Infection, but without recognizable symptoms, was demonstrated in sour cherry (P. cerasus on P. mahaleb), peach (P. persica), chokecherry (P. virginiana var. demissa), rootstock seedlings (P. mahaleb), and apricot (P. armeniaca). Symptoms of ring pox appeared in apricot trees inoculated with the virus of twisted leaf from three sources but not in apricot trees inoculated with the virus from a fourth source. No indications of subsequent infection were obtained when the virus of twisted leaf was inoculated into plum (P. domestica on P. cerasifera), wild cherry (P. emarginata var. mollis), four varieties of apple and one variety of pear.

INTRODUCTION

Twisted leaf (2, 3) has been spreading slowly in sweet cherry orchards in the Okanagan Valley of British Columbia since it was observed first in 1938. It has been increasing in some orchards where it was known and has been appearing also several miles away from previously known infections. Leaf symptoms have been fairly constant in kind but the severity has varied considerably. Fruit symptoms have been observed only rarely, and have usually been associated with the most severe leaf symptoms. Almost all of the natural infections have been in the widely grown Bing variety.

Information on the host range of the virus was needed in order to locate the sources of the infections in the orchards. For this purpose inoculations were made, mainly in 1952 to 1955, into a range of possible hosts.

MATERIALS AND METHODS

Four selections of twisted leaf were obtained from naturally infected cherry trees in three orchards in the southern Okanagan Valley. Selections 1 and 4 were from two trees of the Windsor variety, showing moderately severe leaf symptoms, but no symptoms in the fruit. Selection 2 was from a Bing tree with severely affected leaves and an occasional fruit slightly affected. Selection 3 was from a Bing tree with severely affected leaves and fruits.

The four selections were inoculated into 15 varieties of sweet cherry (Prunus avium on P. avium), into sour cherry (P. cerasus on P. mahaleb), into seedlings of peach (P. persica), into the native chokecherry (P. virginiana var. demissa), into seedlings of the alternate rootstock (P. mahaleb), into apricot (P. armeniaca on P. armeniaca), into plum (P. domestica on P. cerasifera), into the native wild cherry (P. emarginata var. mollis), and into four varieties of apple and one variety of pear.

Inoculations were made direct from the orchard trees with Selections 2 and 3 in 1952, and with Selection 4 in 1953. Unsuccessful inoculations of Selection 1 were made in 1952, with inoculum from a young Bing tree which had been inoculated from the original tree in 1951. Reinoculations of the same trees with Selection 1 were made in 1955 but direct from the original infected tree, and the results are presented here.

Plots were designed to provide for inoculation of each selection into paired trees of each kind or variety. Many of the test trees were killed by the severe winter of 1949-50 and a few could not be replaced by the time inoculations were made. With the exception of apple and pear, each experimental tree was inoculated with a single selection. In almost all cases inoculations were made by inserting two buds from the inoculum tree into the plot tree.

In 1954 Selections 2 and 3 were inoculated together into four apple trees, of the Delicious, Jubilee, Spartan, and Winesap varieties, and into seven Bartlett pears. In 1957 all four selec-

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tions were inoculated into these same trees. Inoculum was taken in 1954 out of sweet cherry and in 1957 out of sour cherry, peach, chokecherry, and apricot.

Inoculum made satisfactory union with the host trees, even apple and pear. Ring-spot contaminants were present in inoculum and in experimental trees, but are not considered to have affected the results.

RESULTS

Attempts were made to determine both the susceptibility of the different kinds and varieties of trees to infection with the virus of twisted leaf, and their ability to display symptoms of the disease. Sweet cherry varieties were considered to be definitely infected when they developed leaf symptoms similar to those expressed by the Bing variety. Experimental sweet cherry trees of different varieties showed leaf symptoms which were remarkably similar in type, though differing widely in severity. Symptomless sweet cherry trees, and trees of other kinds, were considered to be definitely infected when back inoculations into Bing cherry trees produced typical leaf symptoms. In a few symptomless cherry trees an inserted Bing branch was used instead of back inoculation into a separate Bing tree. In a few other cases infection was apparent when a mazzard understock happened to be able to show leaf symptoms.

Sweet Cherry: The results of inoculating four selections of twisted leaf virus into 15 varieties of sweet cherry are shown in Table 1. Only definitely infected trees were included in this table.

Table 1. The symptom expression of four selections of twisted leaf virus in varieties of sweet cherry. All trees definitely infected.

Variety of cherry	Selection 1 No. of trees	Selection 1 Leaf symptoms	Selection 2 No. of trees	Selection 2 Leaf symptoms	Selection 3 No. of trees	Selection 3 Leaf symptoms	Selection 4 No. of trees	Selection 4 Leaf symptoms
Bing	1	slight	2	severe	3	severe	2	moderate
	1	severe					1	severe
Black	1	slight	2	very slight	1	moderate	1	moderate
Republican	1	severe					1	severe
Black	1	none	2	none	1	none	2	none
Tartarian					1	slight		
Deacon	1	none	2	none	2	none		
Hedelfingen					1	moderate		
					1	severe		
Lambert	2	moderate	2	very slight	2	severe		
Napoleon			1	none	2	moderate	2	moderate
(Royal Ann)			1	slight				
Sam	2	none	2	none	1	none	1	none
							1	very slight
Sparkle			2	very slight	1	none	1	none
					1	very slight	1	slight
Star	1	none	1	none	2	none		
Sue	2	none	2	very slight	1	none	1	very slight
					1	very slight		
Seedling S-8-4	2	severe	1	very slight	2	severe	2	severe
Van	2	severe	1	moderate	2	severe	2	severe
			1	severe				
Velvet			1	moderate			1	severe
Victor	1	severe	2	none	1	very slight	2	severe

Sour Cherry: Six inoculated Montmorency sour cherry trees remained symptomless. Back inoculations into sweet cherry showed that three Montmorency trees, inoculated with Selections 2, 3, and 4, were infected with twisted leaf virus. Two trees inoculated with Selection 1 and one inoculated with Selection 4 did not produce symptoms when back inoculated into Bing cherry trees.

Peach: Eight peach seedlings remained symptomless after each of the four selections of twisted leaf virus had been inoculated into two trees. Back inoculations into sweet cherry

showed that all the peach seedlings were infected with twisted leaf virus except one that had been inoculated with Selection 1.

Chokecherry: Eight trees remained symptomless after they had been inoculated in pairs with the four selections of twisted leaf virus. Three trees, two inoculated with Selection 3 and one inoculated with Selection 4, were shown by back inoculations to be infected with twisted leaf virus, while back inoculations from the other five chokecherry trees gave negative results. Thus chokecherry was shown to be capable of infection with the twisted leaf virus, and it was shown that the infected trees remained symptomless.

Mahaleb: Four mahaleb seedlings, inoculated in pairs with Selections 2 and 3, developed no symptoms of twisted leaf. Three were shown by back inoculations to be infected, while one, inoculated with Selection 3, gave a negative result.

Apricot: Table 2 shows the results of inoculating the four selections of twisted leaf virus into Wenatchee apricot trees. These results show that apricot is capable of infection by the virus of twisted leaf. Apricot ring pox (1, 3), was not expected. Its occurrence in trees inoculated with three of the four selections of twisted leaf was remarkable, and seemed to indicate a possible relation between the two diseases.

Prune: Eight Italian Prune trees, inoculated in pairs, remained symptomless. All were back inoculated into Bing with no indications of twisted leaf.

Wild Cherry: Four large trees of the wild cherry (*P. emarginata* var. *mollis*), inoculated in 1955 with the four selections, showed no symptoms of twisted leaf, and all back inoculations produced negative results.

Apple and Pear: Inoculated apple and pear trees showed no signs of being infected with twisted leaf and all back inoculations gave negative results.

Table 2. Results of the inoculation of four selections of twisted leaf virus into Wenatchee apricot.

Symptoms	Selection 1	2	3	4
Number of apricot trees	1	2	2	1
Ring pox, shown by fruit symptoms	present	absent	present	present
Twisted leaf virus, determined by back inoculation into cherry	uncertain	present	present	present

DISCUSSION

This work broadens considerably the known host range of the twisted leaf virus. All varieties of sweet cherry included in the test became infected, though two of them remained symptomless. Sour cherry, peach, chokecherry, mahaleb, and apricot became definitely infected, but without recognizable symptoms of twisted leaf. The only kinds which gave no indications of susceptibility were prune, wild cherry, apple and pear.

These results indicate that in a mixed orchard the elimination of this virus may be impossible. The eradication of chokecherries in the vicinity of orchards may be advisable.

This work is being continued, using a greater number of selections of twisted leaf virus on some of the same hosts and a few other species. Further work is in progress on the virus or viruses causing twisted leaf of cherry and ring pox of apricot. Attempts are also being made to determine the importance of the chokecherry as a virus reservoir.

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THE ASSOCIATION OF THE VIRUS DISEASES TWISTED LEAF OF CHERRY AND RING POX OF APRICOT[1]

T. B. Lott and F. W. L. Keane[2]

Abstract

Twisted leaf of cherry and ring pox of apricot have been present in the Okanagan Valley of British Columbia since 1938 and 1942 respectively and have been spreading slowly. In some locations they have occurred in adjacent trees. Experiments showed that cherry is a host of the ring pox virus, and apricot is a host of the twisted leaf virus. Ring pox was obtained out of 33 of 47 cherry trees which were naturally infected with twisted leaf and were indexed on apricot. Twisted leaf was recovered out of 15 of the 33 test apricot trees. In reciprocal experiments, twisted leaf was obtained out of 26 of 32 apricot trees which were naturally infected with ring pox and were indexed on cherry. Ring pox was recovered definitely out of six and probably out of 10 of the 26 test cherry trees. No ring pox virus was obtained out of symptomless commercial Bing cherry trees, and twisted leaf virus was only rarely found in symptomless commercial apricot trees. A close association of twisted leaf of cherry and ring pox of apricot was demonstrated. The work up to the end of 1959 does not warrant a definite decision as to whether the two diseases are caused by a single virus or by two different viruses, but does indicate the probability of a single virus.

INTRODUCTION

Twisted leaf of cherry (4) and ring pox of apricot (1) have been known in the Okanagan Valley of British Columbia since 1938 and 1942 respectively, and have been studied as separate diseases. In work on the host range of twisted leaf (2) it was found that material from cherry trees infected with twisted leaf produced ring pox symptoms when inoculated into apricots. Thus it was demonstrated that cherry is a host of the ring pox virus. Back inoculations into cherry showed that apricot is likewise a host of the twisted leaf virus. This work showed that some association or relationship exists between the two diseases. Further experiments were undertaken and this paper reports the work up to the end of 1959.

EXPERIMENTAL RESULTS

Cherry trees with twisted leaf indexed on apricot:

Two selections of twisted leaf virus were inoculated into apricot trees of the Wenatchee variety in 1952, another selection in 1953, and one more in 1955. Three of these selections, from one Bing and two Windsor cherry trees, produced ring pox. In two of these cases twisted leaf was subsequently recovered in cherry out of the infected apricot, while in the other case twisted leaf was not recovered in a single back inoculation. The fourth selection, from a moderately affected Bing tree, was inoculated into two apricot trees in 1952, and produced no ring pox in these trees from 1953 to 1959. Back inoculations from these apricot trees into cherry in 1956 showed conclusively that both symptomless apricot trees were carrying the virus of twisted leaf. Although this selection of twisted leaf did not produce ring pox when inoculated directly into apricot, unconfirmed evidence of slight ring pox, in 1 year only, was obtained in three out of five young trees which were inoculated indirectly through an intermediate Bing tree.

This work was expanded by collecting twisted leaf from most districts in the Okanagan and Similkameen Valleys. Source material was obtained from 43 cherry trees in 14 orchards. Foliage symptoms were visible in 40 Bing trees, while one Deacon tree and two Lambert trees were symptomless but were found to be infected when indexed on Bing. Each of these selections was inoculated into one Wenatchee apricot tree. In these tests fruit symptoms of apricot ring pox demonstrated the presence of this virus in 30 of the 43 diseased cherry trees. Thirteen apricot trees did not produce fruit symptoms for at least 2 years after inoculation.

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In back inoculations into Bing cherry, twisted leaf was recovered from 13 of the 30 infected apricot trees and from six of the 13 symptomless apricot trees. However, back inoculations produced negative results in two instances from infected apricot trees and in two instances from symptomless apricot trees.

Symptomless cherry trees indexed on apricot:
Material for indexing was obtained from 18 symptomless cherry trees in two of the same orchards where diseased material had been collected. Of six Bing trees tested, four were free from ring pox and two gave doubtful results. The other 12 cherry trees were of the Lambert variety, which is usually symptomless when infected with twisted leaf, and were found to be carrying neither the twisted leaf virus nor the ring pox virus.

Apricot trees with ring pox indexed on cherry:
In reciprocal experiments, source material of ring pox was obtained from 32 naturally infected apricot trees of the English Moorpark and Wenatchee varieties, in 14 orchards in the southern Okanagan and Similkameen Valleys. Fruit symptoms were visible in all these trees. Material from each of these sources was inoculated into one Bing cherry tree. These tests demonstrated the presence of the twisted leaf virus in 26 of the 32 diseased apricot trees. Six trees did not produce symptoms for at least 2 years after inoculation.

In back inoculations into apricot, fruit symptoms showed the presence of ring pox virus in six of the 26 infected Bing trees, while leaf and bark symptoms in non-bearing apricots indicated the presence of the virus in four more of the infected Bing trees.

Apricot trees, symptomless or nearly so, indexed on cherry:
Material for indexing was obtained from 237 symptomless apricot trees in 11 orchards, from 10 of which diseased material had been obtained. Of these, two trees proved to be infected with twisted leaf virus and 235 trees produced no symptoms in Bing cherry trees for at least 2 years after inoculation.

In growers' orchards there were seven trees that showed slight symptoms which could not be diagnosed definitely as ring pox. When these were indexed on Bing cherry, twisted leaf was obtained in four instances, and three trees produced no symptoms for at least 2 years after inoculation.

Unusual result:
In one case, which is included in the preceding paragraphs, an unusual result was obtained. Material from a grower-owned apricot, severely affected with ring pox, produced twisted leaf when inoculated into cherry. When this same material was inoculated into apricot, no ring pox fruit symptoms were produced over a period of 4 years, but inoculations from this symptomless apricot produced twisted leaf in three Bing trees.

DISCUSSION

Each of the two diseases has been spreading slowly for some years in the Okanagan and Similkameen Valleys. New infections have appeared both close to and some distance from previously known infections. The two diseases have occurred in close proximity in several commercial orchards. In most instances, material from cherry trees with twisted leaf produced ring pox fruit symptoms when it was inoculated into apricot. Back inoculations from the apricot trees often produced twisted leaf symptoms in cherry. In reciprocal tests, material from apricot trees with ring pox usually produced twisted leaf when inoculated into cherry, and some back inoculations from the cherries into apricot produced ring pox. Thus a close association of the two diseases must exist. However in seven of the cases reported, twisted leaf material has been inoculated into apricot trees which remained symptomless for 2 to 7 years, but which transmitted twisted leaf when back inoculated into cherry.

In general, inoculum, both of cherry and apricot, made satisfactory union, and while ring spot contaminants were known to be present, particularly in cherry, they are not considered to have affected the results. However, in considering the instances where negative ring pox results are reported, it should be borne in mind that cases have occurred in commercial orchards where apricot trees, known to have shown severe fruit symptoms in certain years, have been nearly or entirely symptomless in other years, even when carrying a full crop. Furthermore, the standard indicator, Bing, has failed to show the presence of certain selections of twisted leaf (3). In view of these factors, it is considered that the work in British Columbia to the end

of 1959 does not warrant a definite decision as to whether twisted leaf and ring pox are caused by a single virus or by two different viruses, but does indicate the probability of a single virus.

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LEAF CRUMPLE DISEASE OF COTTON IN ARIZONA[1]

Ross M. Allen, Henry Tucker, and Roy A. Nelson[2]

Abstract

Increase of leaf crumple disease of cotton in the Yuma Valley of Arizona was greatest in mid-July of the 1958 season. Substantial and similar yield reductions due to infection were recorded for eight Acala varieties grown both as stubbed and seeded crops. All varieties studied were susceptible to the disease. Two varieties, 124-68 and 124-6, showed greater susceptibility than the others. Yields were reduced 20.6 percent in the seeded crop and 16.8 percent in the stubbed crop. Some yield loss is attributed to reduction of boll size in certain varieties, however, the disease evidently reduces numbers of bolls also. Fiber analyses of seed cotton from healthy and diseased plants were compared. Leaf crumple infection caused severe reduction of the seed index and slight reduction of fiber length. Other fiber characteristics tested were not affected.

INTRODUCTION

Leaf crumple, a virus disease of cotton, probably has been present in Arizona in small amounts for several years but had not been considered an important disease of the crop. In 1958, coincident with increased grower interest in stubbed or ratoon cotton, the disease suddenly became prevalent in both stubbed and first-year or seeded cotton fields of the Yuma Valley and was observed in fields nearly 100 miles east of Yuma.

Descriptions of leaf crumple disease, transmission experiments, and yield reductions have been reported from California (1, 3, 5) where the disease has been found in the Coachella and Imperial Valleys and in the vicinity of Bard, located directly across the Colorado River from Yuma, Arizona. Leaf crumple has been sufficiently severe in the Bard area to warrant consideration of legally enforced host-free periods for control of the disease in that district. Other diseases of cotton attributed to virus infection have been reported (4, 6, 7, 8, 9) but, for the present, are thought to be distinct from leaf crumple.

This report concerns observed effects of leaf crumple virus on stubbed and seeded plantings of several Acala varieties of cotton grown under Yuma Valley conditions during the 1958 season.

MATERIALS AND METHODS

This study was made in a variety test block on the University of Arizona Experimental Farm, Yuma, Arizona[3]. The variety test block which had been arranged as an 8 x 8 Latin square was modified by allowing one member of a pair of adjacent experimental units to remain as a stub crop for the 1958 season and the other member plowed up and replanted in the spring with the corresponding variety. This then formed four replications of a split-plot, randomized block, with varieties as whole plots and the seeded-stubbed comparison on sub-plots. Sub-plots were 33 feet long and 4 rows wide, with rows at 40-inch intervals.

Leaf crumple incidence was recorded and diseased plants were tagged on June 13, July 7, July 22, and August 15, 1958. Disease identification was based on foliar symptoms. Plants from which yield data were taken were marked at first harvest with large yellow cloth strips for future identification. Harvests were made on August 6, October 7, October 29, and December 5, 1958. Yields were calculated on per-plant basis for 176 diseased plants and a like number of healthy plants in the seeded plots, with approximately the same number of plants of each type selected in each plot. Since more disease occurred in the stubbed plots, a comparison was made of 353 plants. Diseased plants were those showing definite foliar symptoms at first harvest without regard to time of appearance of symptoms. Healthy plants showed no visible disease symptoms during the entire growing season and were located in the immediate proximity and same row as their counterpart diseased plants. Plant stands in the seeded and stubbed

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[3] This variety test was established by Dr. Robert E. Briggs, Department of Agronomy, to whom the writers are indebted for permission to make the study.

plots were approximately equal with average spacing of 9 and 10 inches, respectively.

Fiber analyses[4] were made on 1-pound samples taken on August 6. Additional 25-boll samples were collected from seeded cotton plots only, on August 25, 1958, for boll size data.

The statistical analysis was made regarding the over-all design as a split, split-plot, with the comparison of healthy and diseased plants as a subdivision within the sub-plots. Where significant differences were detected, the multiple range test (2) was used to separate means.

RESULTS

Seasonal Increase of Disease

Leaf crumple was recognized in stubbed plants of the test area as early as April 11, 1958. Earlier positive identification was hindered by heavy infestations of melon aphids which cause leaf malformation similar to leaf crumple. As shown by Table 1, only occasional seeded plants appeared diseased on June 13, the first survey date. High initial disease counts in the stubbed plots for all varieties probably indicates systemic, carry-over infection from the 1957 season. Relatively small increases in disease incidence occurred for the periods June 13-July 7 and July 22-August 15. Greatest increase occurred between July 7 and July 22. Increase of leaf crumple progressed in both seeded and stubbed cotton at approximately equal rates despite the presence of greater numbers of infection loci in the stubbed plots.

Table 1. Numbers of plants showing foliar symptoms of leaf crumple infection on four consecutive survey dates in eight varieties of seeded and stubbed Acala cotton during the 1958 season (totals of four replicates).

Variety[a]	Treatment	Date of survey: June 13	July 7	July 22	August 15
124-68	Seeded	0	9	59	59
	Stubbed	43	49	84	88
1517-C	Seeded	1	4	15	17
	Stubbed	14	17	28	33
124-6	Seeded	4	10	39	40
	Stubbed	48	55	90	95
A-44	Seeded	5	8	20	20
	Stubbed	30	37	56	60
44-WR	Seeded	0	6	9	9
	Stubbed	9	12	20	22
44-10	Seeded	2	6	13	13
	Stubbed	18	21	28	29
4-42	Seeded	1	6	14	14
	Stubbed	23	25	46	47
504	Seeded	1	8	16	16
	Stubbed	44	48	53	55

[a]All varieties listed are Acala types.

Varietal Susceptibility

A highly significant varietal difference in number of infected plants was found in the seeded treatment (Table 2), while stubbed varieties differed at just below the 5 percent level. The combined data for seeded and stubbed treatments show significant differences among varieties; 124-68 and 124-6 have greater susceptibility to leaf crumple. Other varieties are less susceptible with no differences among them. Since no interactions occurred, the differences among varieties are considered the same for seeded and stubbed treatments. A comparison of the treatment means showed less than half as many infected plants were found in the seeded plots as in the stubbed, which was highly significant.

[4]The cooperation and assistance of the staff of the Cotton Laboratory, University of Arizona, Tucson, is appreciated for performing the fiber analyses.

Table 2. Varietal susceptibility to leaf crumple infection as indicated by average number of infected plants per plot on August 15, 1958.

Variety	Infected plants per plot (means of four replicates): Stubbed	Seeded	Combined means	Range[a]
124-68	22.00	14.75	18.38	a
124-6	23.75	10.00	16.88	ab
A-44	15.00	4.75	9.88	bc
504	13.75	2.25	8.00	bc
4-42	11.75	3.50	7.62	bc
1517-C	8.25	3.25	5.75	c
44-10	7.25	2.50	4.88	c
44-WR	5.50	0.75	3.12	c
All	13.41	5.22	9.31	
$s\bar{x}$	4.36	2.33	2.40	

[a]Any two variety means followed by the same letter are not significantly different at the 1% level, as determined by Duncan's Multiple Range Test.

Yield Reduction

Highly significant differences due to disease were found when yields for all eight varieties were averaged by treatment. These differences on a per-plant basis (Table 3) amounted to 20.6 percent reduction in seeded cotton and 16.8 percent in stubbed. Since there was no apparent interaction between variety and disease, the losses due to disease may be regarded as consistent for all varieties. A comparison of the reduction of yield (pounds per plant) due to disease was not significantly greater for seeded than for stubbed cotton.

Table 3. Effect of leaf crumple infection on yields of eight Acala cotton varieties grown as seeded and stubbed plants, Yuma Valley, 1958. Yield expressed as mean pounds of seed cotton per plant.

Treatment	Variety: 124-68	1517-C	124-6	A-44	44-WR	44-10	4-42	504	All
Seeded									
Number plants compared	59	15	30	20	9	13	14	16	176
Diseased	.3245	.2395	.2335	.2065	.4062	.2450	.4925	.1752	.2904
Healthy	.3625	.3318	.3630	.3110	.4338	.3180	.5095	.2950	.3656**
Stubbed									
Number plants compared	73	24	76	44	20	23	46	47	353
Diseased	.3432	.5662	.4308	.4582	.5000	.4598	.5400	.3595	.4573
Healthy	.4502	.6455	.4710	.6275	.5518	.6215	.5895	.4385	.5494**

**Significantly different at 1% level.

Fiber Properties

Leaf crumple disease had no effect on most of the essential fiber characteristics. Comparative data (not included) for seeded and stubbed cotton showed that the disease had no greater effect on fiber from seeded than from stubbed cotton. When the data for seeded and stubbed plantings were combined over varieties, a highly significant difference was recorded for seed index. This showed that smaller and lighter seeds developed on infected plants. Fiber length, as indicated by the upper half mean (U.H.M.), was reduced slightly by the disease. Disease effects, where found, were approximately equal for all varieties. The means for the combined analysis are shown by Table 4.

Boll Size

Because the original samples taken for fiber analysis were collected from an undetermined number of bolls, the boll size could not be calculated. To obtain this information, additional 25-boll samples were taken during harvest from healthy and diseased plants in each of the

Table 4. Effect of leaf crumple infection on fiber properties of eight varieties of Acala cotton. Figures are means for four replicates, seeded and stubbed combined.

Fiber properties	Variety								
	124-68	1517-C	124-6	A-44	44-WR	44-10	4-42	504	All
Lint percent									
Healthy	37.0	29.8	37.6	37.0	34.8	36.9	37.7	32.6	35.0
Diseased	38.4	31.5	37.4	37.0	34.5	37.9	37.6	31.5	35.7
Lint index[a]									
Healthy	8.56	5.55	8.51	7.69	7.05	7.21	8.10	6.90	7.45
Diseased	8.51	5.85	7.13	7.51	7.14	8.10	7.94	6.50	7.33
Seed index[b]									
Healthy	14.6	12.9	12.7	13.1	13.2	13.8	13.4	14.1	13.5
Diseased	13.6	12.6	11.9	12.8	13.5	13.4	13.2	14.0	13.1 **
Length (U.H.M.)									
Healthy	1.10	1.11	1.09	1.08	1.11	1.10	1.12	1.08	1.10
Diseased	1.08	1.10	1.07	1.07	1.11	1.08	1.11	1.05	1.09*
Strength (Pressley)[c]									
Healthy	3.74	4.07	3.64	3.42	3.72	3.49	3.88	3.98	3.74
Diseased	3.57	4.07	3.52	3.45	3.69	3.50	4.01	3.99	3.72
Fineness (Micronaire)									
Healthy	4.51	3.18	4.29	4.14	4.16	4.40	4.49	3.67	4.10
Diseased	4.39	3.27	4.11	4.07	4.33	4.43	4.41	3.45	4.06

*Significant at the 5% level.
**Significant at the 1% level.
[a]Grams weight of fiber from 100 seeds.
[b]Grams weight of 100 seeds.
[c]Number of pounds required to break 1 mg of lint cut to a standard length of 0.587 inches.

Table 5. Average number of bolls required for yield of 1 pound of seed cotton from seeded, healthy and leaf crumpled cotton plants[a].

Plant condition[b]	Variety								
	124-68	1517-C	124-6	A-44	44-WR	44-10	4-42	504	All
Healthy	59.06	73.95	74.71	63.42	60.07	61.90	62.52	69.53	65.84
Diseased	65.19	77.09	72.54	66.26	65.50	61.16	65.18	73.65	68.45**

**Significant at 1% level.
[a]Average derived from four 25-boll samples per variety (one sample per plot).
[b]Based on presence or absence of foliar symptoms on August 25, 1959.

seeded plots. None were taken from stubbed plots.

Table 5 shows the results of these comparisons. Leaf crumple caused reduction of boll size in six of the eight varieties examined. Since there was no significant interaction between variety and plant condition, a comparison of boll size for healthy and diseased plants was made for all varieties combined. Leaf crumple caused a highly significant reduction in boll size.

DISCUSSION

The foregoing data clearly show that rapid increase of symptom expression of leaf crumple disease took place during a relatively short and specific period in mid-July of 1958. Although population counts are not available for the whitefly vector, Bemisia tabaci (Genn.), greatest activity of these insects in the field was observed in mid-June and seemed to decline shortly thereafter. The period of maxium disease increase probably corresponds to this earlier period of whitefly activity.

Erwin (3) noted 71 percent yield reduction in comparing diseased and non-diseased Acala 4-42 cotton in the Imperial Valley when infection occurred earlier than July 21-August 6, 1958. Practically all infection in the Yuma area occurred before these dates. Yield reductions at Yuma were less than 1/3 as great as those reported from the Imperial Valley.

In the Imperial Valley second year (stubbed) cotton was not damaged by leaf crumple as much as first year or seeded cotton. In Yuma, more loss per diseased plant seemed to occur

in the seeded cotton compared with the stubbed, but this difference was not significant.

While a small proportion of the yield loss, approximately 4 percent, may be attributed to reduction of boll size by leaf crumple it appears that the principal loss results from failure of diseased plants to set as many bolls as non-infected plants. Yield reductions were found in all varieties, two of which did not show disease effect on boll size. Failure to set bolls appears substantiated by the fact that greatest seasonal disease increase, with probable physiological shock to the plants, took place in late June or early July when flowering and boll setting is normally abundant.

Leaf crumple causes economically important losses in both stubbed and seed plantings. Although loss of yield per plant appears greater in seeded cotton, much more disease occurs in stubbed plants as a result of carry-over, systemic infection plus seasonal increase equaling that in seeded areas. Larger total loss for a given season should be expected from stubbed plantings. Where leaf crumple is a problem the practice of stubbing cotton, especially the more susceptible varieties, should be discontinued.

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DODINE, AN OUTSTANDING FUNGICIDE FOR PECAN SCAB CONTROL

John R. Cole[1]

After the prepollination spray applications had been made in 1958 a quantity of dodine (dodecyl-guanidine acetate 70%), trade named Cyprex[2], was obtained to test for the control of pecan scab, caused by Fusicladium effusum Wint. The trees of the Schley variety set a light crop of nuts that year in the orchard at Albany, Georgia. Nevertheless, the trees sprayed with four cover applications of dodine at the rate of 2 pounds in 100 gallons of water retained their foliage better and also produced heavier nuts, according to count per pound, than similar trees sprayed with the same number of applications of bordeaux mixture, zineb or ziram, and at the same times.

Because of the excellent preliminary tests of 1958, dodine was included in the experimental tests on trees of the Schley variety near Fort Valley, Georgia, in 1959. Each treatment plot consisted of a single tree replicated nine times. The 41-year-old trees required an average of 35 gallons of spray material per application. The material was applied with a speed sprayer and the trees were circled.

Weather conditions favored the development of scab on both foliage and nuts. Beginning in April, when 3.39 inches of rain fell on 5 days and ending in September, when 4.44 inches fell on 10 days, there was never a time during the 6-month nut-development period when scab was not a threat. The wettest month was July, when 10.03 inches of rain fell on 15 days; because much of this precipitation came in late afternoons and evenings, ideal infection periods for scab development resulted. The leaves and nuts were seldom dry during this period, and at times it was difficult to drive a spray machine into the orchard because the ground was boggy. From April through September 30, 31.16 inches of rain was recorded at the U. S. Horticultural Field Station, 1 mile from the experimental plots in the Mathews orchard.

Scab infections appeared early in the season and on May 15 totaled 34 percent on the foliage of the check trees. At that time only 4 percent of the leaves on the trees sprayed with 2-100 dodine were infected, as compared with 19 percent on those sprayed with 6-2-100 bordeaux mixture, 22 percent on those sprayed with 2-100 ziram and 17 percent on those sprayed

Table 1. Effects of protective fungicidal spray applications on yield per Schley pecan tree and number of nuts per pound, Fort Valley, Georgia, 1959.

Fungicide	Concentration[a] pounds per 100 gallons	Number and description of spray applications	Yield per tree[b] (pounds)	Nuts per pound (number)
None (check)	--	--	1	120
Dodine	2-100	2 prepollination[c] + 4 cover[e]	88	67
Dodine	2-100	2 prepollination[c] + 2 cover[d]	41	89
Bordeaux mixture	4-1-100	2 prepollination[c] + 4 cover[e]	10	91
Ziram	2-100	2 prepollination[c] + 4 cover[e]	8	109
Zineb	2-100	2 prepollination[c] + 4 cover[e]	13	93

[a] 15 percent wettable parathion at the rate of 2-100 was added to 1st and 4th cover sprays on all trees including the checks.
[b] average of 9 trees spaced 10 trees per acre.
[c] applied April 9 and 20.
[d] applied May 11 and June 4.
[e] applied May 11, June 4, July 3 and 30.

[1]Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Albany, Georgia.

[2]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guaranty or warranty of the product named and does not signify that the product is approved to the exclusion of other comparable products.

with zineb. These results indicated that dodine would give almost perfect control of this disease. In addition, scab counts made on August 13 showed that an estimated 25 percent of the nuts had dropped from the check trees and the remainder were badly scabbed, whereas none of the nuts had dropped as a results of scab from the dodine-sprayed trees (six applications) and approximately 75 percent were completely free of scab. Most of the nuts on the trees sprayed with bordeaux mixture, ziram or zineb were affected by scab in various degrees, light to severe, and some dropping had occurred. The effects of treatment on yield and weight of nuts are shown in Table 1.

The data in Table 1 show that dodine[3], applied according to the spray schedule, gave outstanding control of scab as compared with other treatments. Even four applications of dodine was better than the six applications of bordeaux mixture, zineb or ziram. Because weather conditions were favorable for scab development in 1959 the disease was more destructive on both foliage and nuts than at any other time since 1949. As a result of the destructiveness of scab only 1 pound of nuts was harvested from the check trees, whereas in 1958[4] 13 pounds was harvested. Furthermore, all treatments gave commercial control of the disease in 1958[4], a year of moderate rainfall.

In view of the excellent results obtained with dodine in 1959 the writer expects to expand his tests during 1960.

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[3]Dodine cannot be recommended (as of January 30, 1960) for use on pecans, since evidence has not been developed to prove it will leave no residue or/and tolerances have not been set under Public Law 518.

[4]Scab can be controlled on the Schley variety of pecan in Central Georgia with proper timing and thorough spraying. Plant Disease Reptr. 43: 6. 1959.

EVALUATION OF FUNGICIDES FOR CONTROL OF POWDERY MILDEW, AS WELL AS OTHER DISEASES, OF APPLE

Harry L. Keil and Roy A. Wilson[1,2]

Summary

Rome Beauty apple trees were sprayed for control of powdery mildew (Podosphaera leucotricha (Ell. & Ev.) Salm.) in the field at Beltsville, Maryland. Under moderately heavy mildew conditions micronized wettable sulfur at 1 or 2 pounds per 100 gallons of water gave as good control as Karathane WD without injury to apple. Karathane Liquid Concentrate also gave control as good as Karathane WD when used at equivalent active-ingredient levels. Dodine (Cyprex) at 1.5 pounds gave as good control as sulfur or Karathane but was significantly poorer at lower dosages. For control of scab and late-summer diseases dodine appeared much superior to other chemicals included in the test.

INTRODUCTION

Powdery mildew of apple has become progressively more prevalent and destructive since organic compounds have been substituted for sulfur in apple spray schedules. Until we find a chemical compound which will control mildew as well as other apple diseases we must put sulfur back into the schedule or substitute some other mildew toxicant for it. Many apple growers hesitate to use sulfur because of its possible phytotoxicity during high temperatures. However, everyone more or less agrees that several years ago when sulfur was used at high concentrations for scab control it also held mildew at such a low level that the latter disease was rarely thought of as a problem.

The present study was conducted to see whether low concentrations of sulfur control mildew as well as Karathane (2-(1-methlheptyl)-4,6-dinitrophenyl crotonate) does without injury to the host. Because previous studies had indicated that dodine, a very good apple scab control agent, also gave some control of mildew this chemical was included at several dosages to see whether levels necessary for control of scab would also control mildew. Dodine is the coined common chemical name of n-dodecylguanidine acetate, manufactured as Cyprex dodine 65-W.

MATERIALS AND METHODS

Rome Beauty apple trees (10 to 12 feet) used in this study were borrowed from another department which had applied with a speed sprayer six applications (April 30, May 13, 27, June 15, 29, and July 15) of fungicide-insecticide. Fungicides used in the general spray program were Puratized Agricultural Spray plus glyodin (calyx and first cover), glyodin (second cover), and three additional cover sprays of captan. The powdery mildew sprays (Table 1) were superimposed on these trees and applied independently of the general spray program. The experimental design consisted of single-tree treatments replicated six times in a randomized-block design. Six sprays were applied with a portable trigger gun at a pressure of 500 psi. Applications were made April 21 (pink), May 4 (calyx), May 19, June 4, 23, and July 16 (cover sprays). In order to facilitate wetting of the foliage and fungus Tween 20 (polyoxyethylene sorbitan monolaurate) was included in all sprays except the dry check.

Foliage readings were taken July 23 and fruit records September 16. Leaf counts were obtained by picking and scoring the fourth leaf from the tip of 100 randomly selected terminals per tree. Six hundred leaves were scored for each chemical. Fruit counts were based on 100 apples selected at random per tree, or a total of 600 per chemical.

All data were statistically analyzed by comparing the means by the Duncan Multiple Range Test (2).

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[1]Respectively, Pathologist and Biological Aid, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.
[2]We wish to thank Rohm and Haas Company, American Cyanamid Company, and Nationwide Chemical Company for supplying gratis Karathane Emulsion Concentrate, Cyprex dodine 65-W and Nabac, respectively.

Table 1. Effect of various fungicides on powdery mildew and other diseases of Rome Beauty apples (in rootstock orchard), Beltsville, Maryland, 1959.

Chemical[a]	Amount per 100 gallons of water (pounds)	Average percent of terminals showing disease on July 23[b]		Average number of fruits showing disease on Sept. 16[b]	
		Powdery mildew	Scab	Sooty blotch	Fly speck
Karathane WD (25%)	0.5	4.5 a	31.5 b	98.2 d	90.2 d
Micronized wettable sulfur	2.0	8.8 ab	41.7 bc	97.3 d	78.5 d
Karathane Liquid Concentrate (48%)	--[c]	10.7 abc	38.3 bc	96.8 d	75.7 d
Dodine (65%)	1.5	11.8 abc	0.0 a	37.5 a	13.5 a
Karathane WD (25%) plus dodine (65%)	0.25 +0.5	14.3 abc	0.5 a	82.3 cd	58.5 c
Micronized wettable sulfur	1.0	15.7 abc	61.7 d	92.5 cd	83.7 d
Micronized wettable sulfur	0.5	18.7 bc	35.3 bc	98.5 d	82.8 d
Dodine (65%)	1.0	21.0 c	0.7 a	62.2 b	37.8 b
Dodine (65%)	0.5	36.3 d	0.7 a	77.7 bc	52.8 bc
Control (water)	--	50.7 e	46.8 bcd	98.2 d	84.5 d
Control (dry)	--	50.7 e	41.3 bc	98.2 d	81.7 d
Nabac wp(25%)	0.5	57.7 e	52.5 cd	96.5 d	85.2 d

[a]All treatments except the dry control included Tween 20 (100 ml per 100 gallons) to aid wetting.
[b]Values followed by same letters not significantly different at 5% level (Duncan Multiple Range Test).
[c]0.25 pint.
[d]Caused objectionable enlargement of lenticels.

RESULTS AND DISCUSSION

Data (Table 1) show it is possible to get comparable powdery mildew control, without injury, with low levels of sulfur or Karathane. Statistically, sulfur gave at the 1- or 2-pound level control equal to that obtained with 0.5 pound of Karathane WD. This result is particularly noteworthy because temperatures (90°F or over) inducing sulfur burn were present 15 days during the spray period (April 21-July 16). Sulfur applied at 0.5 pound showed significantly poorer control than the 1-pound rate, indicating that the breakpoint is somewhere between these two levels.

It would seem that sulfur, although known to cause injury at high concentrations, might be included in the spray schedule at low dosages which are safe or tend to give very little injury while providing satisfactory disease control. Data reported herein indicate that 1 to 2 pounds of micronized wettable sulfur might be satisfactory. Certainly it should be possible to use this material on non-sulfur-sensitive varieties and on those apples for the cannery for which finish is not of prime importance. Use of sulfur permits considerable saving over Karathane.

It is interesting that data recently published by Dickens and Henderson (1) show under Colorado conditions sulfur applied three times (cluster-bud, calyx, and first cover) at 6 pounds per 100 gallons gave, without injury, better control of powdery mildew than Karathane WD (0.75-lb.) applied in these same sprays as well as in two additional cover sprays. Although these investigators point out that sulfur cannot be used in the cover sprays because of russeting caused during periods of high temperature, one wonders whether low concentrations of sulfur would be as effective without being phytotoxic during these same conditions.

The data (Table 1) also show that Karathane Liquid Concentrate, when used at equivalent active ingredient, is statistically as effective for mildew control as the wettable dust formulation without evidence of injury. The data further indicate that 0.25 pound of Karathane WD in combination with dodine is as effective on mildew as 0.5 pound of Karathane WD alone. This might be a worthwhile combination because dodine controls scab and the Karathane the mildew. It would be interesting to see how effective various combinations of these two chemicals would be against both of these diseases.

It is noted that all levels (0.5, 1, and 1.5 pounds) of dodine gave significantly better control of mildew than either the dry or wet check. Only the 1.5-pound level, however, was significantly as good as the best treatments of sulfur and Karathane. Dodine caused objectionable lenticel enlargement at this level but not at other dosages tried. Of course, if used at this rate it could not compete at current prices. Also because of present label claims it would be necessary for the manufacturer to get government approval to change the label in order that the material could be used beyond the first cover application.

Nabac (2, 2-methylene bis (3, 4, 6-trichlorophenol)), the last chemical listed in Table 1, failed to control powdery mildew.

It is noteworthy under conditions of these tests there was no difference in the incidence of mildew on dry or wet (water) checks. Both treatments showed the same average number of terminals infected by mildew.

Because of poor timing of applications in the general fungicide-insecticide spray program, scab (Venturia inaequalis (Cke.) Wint.) and late-summer diseases became very active in this orchard, thus offering an opportunity to test the mildew chemicals on these diseases. Under these conditions data in Table 1 show that all chemicals except dodine gave very poor control of terminal foliage scab. Dodine gave outstandingly good control of this disease at all levels and with all combinations tested.

Although control of sooty blotch (Gloeodes pomigena (Schw.) Colby) and fly speck (Leptothyrium pomi (Mont. & Fr.) Sacc.) leaves something to be desired dodine again was best of the chemicals tried. Against both of these diseases the 1.5-pound dosage of dodine was significantly better than the 0.5- and 1-pound level. The two lower dosages did not differ significantly one from the other, but they were, however, significantly better than most of the other chemicals. These results probably indicate that where dodine is used in a full spray schedule it should tend to give satisfactory control of late-summer diseases.

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NEW TYPE OF SYMPTOMS ON VERTICILLIUM WILT OF COTTON

C. Bazán de Segura

One of the common symptoms of Verticillium wilt of cotton, caused by *Verticillium albo-atrum*, is chlorotic areas on the leaf margins and between the principal veins, causing a mottled appearance (Fig. 1).

FIGURE 1.

During the present 1959-60 season Verticillium wilt of cotton has been very severe along the Rimac Valley (Lima-Perú), and a different type of symptom has been observed on the leaves. The leaf veins and the tissues adjacent along them become purple and later turn brown and necrotic (Fig. 2). In addition, on other foliage on the same branch purple, more or less circular spots, 4 to 5 mm in diameter, are produced which become brown and necrotic (Fig. 3).

FIGURE 2.

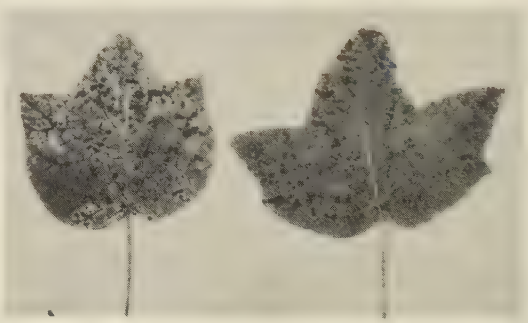

FIGURE 3

The first samples with the symptomatology noted were found on susceptible varieties of cotton in experimental fields at La Molina.

The cultures made of the lesions (veins and spots) in potato-dextrose agar medium produced 80 percent of pure culture of *Verticillium albo-atrum*.

We believe that this symptomatology is produced in very susceptible varieties of cotton, when conditions are favorable to the disease.

LIMA, PERU

THE GANGRENA DISEASE OF POTATO IN PERU

C. Bazán de Segura

The gangrena disease of potato is caused by the fungus *Thecaphora solani*. E. V. Abbott (1), who studied this disease in Peru and called it roña, says that it is widely distributed in the mountains of this country, where it is the most important potato disease, sometimes causing complete loss of many of the affected tubers. He ascribes the disease to *Spongospora subterranea*.

Some years later, Barrus and Muller (2) found in the Andes of Venezuela a new disease on tubers of potato, whose common name was buba. They determined the fungus *Thecaphora solani* as the cause of this disease, which was very similar to the roña of Peru. The disease is called gangrena, to differentiate it from roña (powdery scab).

At the Agricultural Experimental Station El Valle (Venezuela) gangrena was produced by planting healthy tubers in pots containing a mixture of soil with macerated affected tubers. Ochoa, at La Molina (1958), worked out the same experiment with the same results.

The gangrena disease in Peru was considered as an Andean disease only. Nevertheless, A. Quevedo found it (1954) on *Solanum stoloniferum* which was cultivated at La Molina in the greenhouse. In 1958 we found the disease on industrial fields at the Bocanegra farm, Lima (Rimac Valley), near the sea, producing losses up to 50 percent of the crop on the Peruanita variety. On the same variety in 1959 we determined the gangrena in the Cañete Valley (150 kms south from Lima), but only on very few tubers. In the same year at Bocanegra and fields around, the gangrena produced more than 80 percent damage to the crops of the Peruanita variety.

The Peruanita variety was cultivated at Bocanegra, San Agustin and Santa Rosa (Rimac Valley) 8 years ago, and in the last years it has been used as the only variety, because of its adaptation to the zone and good yields. The farmers plant the potato year after year on the same fields, with "seed" (tubers) from the mountains.

According to farmers in the highest part of the Rimac Valley, the disease is not present. But in the lowest parts, where the soil is very wet and salty, the disease produced 60 to 80 percent losses. Farmers said that they observed it for the first time in 1957, in a few tubers. In 1958 the disease caused 50 percent loss and in 1959 up to 80 percent of the crop was affected by the disease. We visited the different storages and confirmed the opinion of the farmers, that the disease is only present in the lowest parts of the zone.

Unfortunately we do not have sufficient information on the disease, but from observations we can deduce the following points:

1) The gangrena disease of potato is transmitted by the "seed" (tubers).

2) This disease is favored by high humidity and high salinity of the soils.

3) The planting of potato in the same fields, year after year (without rotation), increases the disease when the pathogen is present.

4) As the gangrena disease on the Coast was found only on the Peruanita variety, this variety is evidently very susceptible.

Other varieties, such as Huasahuasi, have been cultivated on the Peruvian Coast for many years, but we did not find the disease on that variety.

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LIMA, PERU

RELATIONSHIP OF NEMAS (NEMATODES) WITH THE ROOT ROT OF PINE SEEDLINGS AT THE E. A. HAUSS STATE FOREST NURSERY, ATMORE, ALABAMA[1]

B. E. Hopper and W. H. Padgett[2]

Since Lindgren and Henry (2) reported that the root rot at the W. W. Ashe Nursery was controlled with ethylene dibromide it has been assumed that nemas (nematodes) were involved. However, Foster[3] found that ethylene dibromide did not provide adequate control of a similar root rot in Georgia nurseries. The serious damage caused by root rot to pine seedlings prompted the Southeastern Forest Experiment Station of the United States Forest Service in 1956 to conduct a nema survey of all the pine forest nurseries in the South. This survey failed to disclose any association between the root rot and the presence of plant-parasitic nemas (1).

In the fall of 1957 root rot was found in a localized area within the E. A. Hauss Nursery at Atmore, Alabama. Four soil samples were collected at that time, one from the center of the root rot area, a second at the margin, a third 20 feet from the margin, and the fourth 40 feet from the margin. From these samples the nema genus Tylenchus Bastian, 1865 was found to be abundant within the center of the root rot area, dropped to few at the margin, and were almost non-existent in the latter two samples[4].

Nema population studies were initiated the following growing season to determine the relationship between nemas and the root rot. It was of particular interest to collect additional information regarding the occurrence of the Tylenchus sp. with the root rot. Soil samples were collected from 19 locations in and adjacent to the known root rot area for a total of 12 collection dates. Each sample was a composite of 12 soil tube borings obtained about a fixed point from the upper 6 inches of the seed bed. In the laboratory each sample was thoroughly mixed and the volume reduced to 1 pint. The samples were processed by the Seinhorst Elutriation method and, after 24 hours, total nema counts recorded.

The results of the study are presented in Table 1.

Symptoms of the root rot appeared 4 weeks before the build-up of any of the suspect pathogenic nemas. From the time of seedling emergence to the manifestation of the root rot, only eight suspect nemas were recovered from 57 soil samples.

The nema Tylenchus was observed to be associated with the root rot only after the root rot had become severe. Thus, the nema was thought to thrive on the pathogenic and/or saprophytic fungi associated with the diseased roots.

The junior author found that the fungi Fusarium sp. and Sclerotium bataticola were recovered from seedlings collected 3 weeks after emergence. This was approximately 5 weeks before top symptoms of the disease appeared. Furthermore, the junior author has observed that the occurrence of Sclerotium bataticola increased with each sampling period[5].

As root rot appeared 5 weeks before the build-up of the suspect pathogenic nemas, the observations indicate that nemas are not the cause of the root rot. Evidence that a fungal pathogen was responsible was more strongly indicated.

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[1]Supported in part by a grant from the Southeastern and Southern Forest Experiment Stations of the United States Forest Service.

[2]Both formerly associated with the Department of Botany and Plant Pathology, Alabama Polytechnic Institute, Auburn, Alabama.

[3]Foster, A. A. Black root rot of southern pine seedlings in forest nurseries. (unpublished)

[4]A soil sample sent in by A. A. Foster of the United States Forest Service, Macon, Georgia, collected from a root-rot area within the Horseshoe Bend Nursery at Glenwood, Georgia, similarly contained very many specimens of Tylenchus sp. (over 1000 per pint of soil).

[5]Unpublished data.

Table 1. Total numbers of nemas of various groups for each collection date.

Collection number	Date	Nematodes recovered: Non-suspect: Saprophytes	Mononchids	Dorylaimids	Alaimus sp.	Suspect pathogens: Tylenchus sp.	Triplonchium sp.	Xiphinema americanum	Helicotylenchus sp.	Trichodorus christiei	Pratylenchus sp.	Aphelenchids	Criconemoides sp.	Total
1	4/8	748[a]	527	68	19	17	0	4	3	0	0	0	0	1386
2	4/21	2175	175	46	11	1	0	1	1	0	0	0	0	2410
Seed planted														
3	5/5	2668	94	39	5	14	0	3	1	0	0	0	0	2824
Seed germination														
4	5/16	1842	216	200	2	0	3	0	0	0	0	0	0	2263
5	5/31	2738	474	326	10	0	0	1	0	1	0	0	0	3550
6	6/16	2180	679	331	20	0	1	0	1	1	0	0	0	3215
Topsymptoms of root rot evident														
7	7/2	1981	435	297	10	0	0	0	0	0	0	0	0	2723
8	7/16	3110	1031	261	12	0	0	0	0	0	0	0	0	4414
9	7/28	1066	1617	438	40	253	24	1	0	0	0	11	0	3450
10	8/12	454	362	187	9	92	3	0	8	0	0	0	0	1115
11	9/7	1809	1449	280	33	732	37	2	4	115	1	1	1	4464
12	10/7	1481	2443	588	0	221	317	2	0	141	0	0	1	5194

[a]Each figure represents the number of individuals, of the group indicated, recorded for that particular collection period (that is, the total number found in 19 pints of soil).

CENTRAL EXPERIMENTAL FARM, CANADA DEPARTMENT OF AGRICULTURE, OTTAWA, ONTARIO

FURTHER OBSERVATIONS ON THE SCAR SKIN DISEASE OF APPLE[1]

D. F. Millikan and H. W. Guengerich

Abstract

Scions from healthy apple varieties grafted and fruited on a diseased tree indicated that several apple varieties are susceptible to the scar skin disease. These include Red Delicious, Stark's Earliest, Red Gold, Staymen and Rome Beauty. Lodi, Minjon and Golden Delicious appear to be tolerant. Field observations indicate that Virginia Crab and Jonathan are susceptible to this disorder. The susceptibility of Virginia Crab indicates that only trees propagated from clones bearing healthy fruit should be used for orchard planting.

The scar skin disorder of apple was first reported in Missouri as a disease on the Red Delicious in 1956[2]. At that time it was found in four orchards in a north Missouri apple growing area. Since that time additional diseased trees have been found in two orchards in another area of the State. Although the first reports indicated that Red Delicious appeared to be the only variety affected, additional surveys and experimental evidence indicate that other varieties are sensitive to the disease.

SUSCEPTIBILITY OF VIRGINIA CRAB

In 1956 a fruiting limb of Virginia Crab retained on a tree top-worked to Red Delicious bearing severely scar-skinned fruit was observed to have abnormal fruit. The Virginia Crab fruit when compared with that from healthy trees was reduced in size and blemished with a corky development in the skin tissues (Fig. 1). This was confirmed the following year in an orchard where two rows of Virginia Crab originally top-worked with Turley were subsequently grafted to Red Delicious, leaving a few limbs of Virginia Crab. In all cases where the Red Delicious and Virginia Crab bore fruit on the same tree and the Delicious showed symptoms of scar skin, the Virginia Crab fruit was reduced in size and blemished. Conversely, if the Red Delicious fruit was normal in size and color, the Virginia Crab fruit appeared to be quite healthy in size and color. These observations were confirmed in 1958 and 1959. On the basis of these observations it appears that Virginia Crab may be used as an indicator for the scar skin disorder.

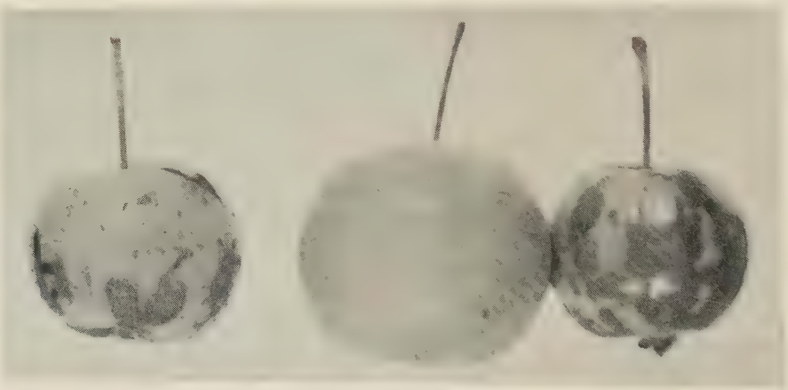

FIGURE 1. Virginia Crab fruit harvested from fruiting understock top-worked with Red Delicious. Left and right, Virginia Crab grafted to scar skin infected Red Delicious; center, Virginia Crab grafted to healthy Delicious.

1 Journal Series Paper No. 2118, Approved by the Director of the Missouri Agricultural Experiment Station.

2 Millikan, D. F. and W. R. Martin, Jr. 1956. An unusual fruit symptom in apple. Plant Disease Reptr. 40: 229-230.

SUSCEPTIBILITY OF OTHER VARIETIES

In surveys using Virginia Crab as an indicator, Jonathan was found susceptible to the scar skin disease. Typical symptoms are a reduction in size of the fruit and a very mild mottle (Figs. 2, 3). These symptoms are accompanied by a mild off-flavor. Golden Delicious appears to be quite tolerant to this disease and shows no symptoms, but the fruit from affected trees are mildly off-flavored.

In 1958 scions from 15 standard and new varieties of apple were grafted to a diseased tree. In 1959 eight of these scions bore fruit, and five of the eight showed symptoms of reduced fruit size and a mottle or blemish in the skin. The most pronounced symptoms were noted on Stark's Earliest, which showed symptoms on the skin of the fruit as early as June 15. Other varieties showing symptoms of infection on the fruit include Delicious, Red Gold, Staymen and Rome Beauty. Other than Red Delicious, none of these varieties were as severely affected as Stark's Earliest. Lodi, Golden Delicious and Minjon appeared to show no symptoms, but flavor tests were not determined.

FIGURE 2. Jonathan apples at harvest time. From left to right, samples 1 and 5 were picked from tree carrying scar skin infection. Samples 2 and 4 were picked from healthy tree. Sample 3 is a typical scar skin affected fruit picked from Delicious limb grafted on Jonathan tree bearing samples 1 and 5.

FIGURE 3. Jonathan apples picked June 15, 1957. On extreme right, apple picked from healthy tree. Samples 1, 2, 3 and 4 were harvested from limb of Jonathan grafted on Hibernal trees originally grafted to Red Delicious showing scar skin.

DISCUSSION

This report points out the advisability of using as an indicator only those Virginia Crab clones bearing normal fruit. Since the demonstration of the infectious nature of stem pitting[3], the variety Virginia Crab has become a useful indicator for this disease. Our observations indicate that the variety is also a good indicator for scar skin and therefore only clones bearing normal-sized and colored fruit should be used. Preliminary tests indicate that Stark's Earliest also may be a useful indicator for transmissible fruit disorders in apple. The possibility of symptomless varietal hosts is also pointed out.

MISSOURI AGRICULTURAL EXPERIMENT STATION, COLUMBIA

[3]Guengerich, H. W. and D. F. Millikan. 1956. Transmission of the stem pitting factor in apple. Plant Disease Reptr. 40: 934-938.

THE INFECTION OF PEAR ROOTLETS BY PHYTOPHTHORA CACTORUM[1]

D. L. McIntosh[2]

Abstract

In British Columbia orchards, pear nursery stock often fails to grow satisfactorily after it is planted, and bearing pear trees are affected by pear decline. Phytophthora cactorum was isolated frequently from soil in orchards with decline. When root systems of pear seedlings were exposed to inoculum of P. cactorum, feeder roots became infected and growth in the tops was greatly reduced. The possibility that Phytophthora spp. may be implicated in the development of these disorders is discussed.

Two disorders affecting pear trees are causing great concern to orchardists and to propagators of nursery stock in British Columbia. One is the decline in vigor and productivity of bearing pear trees, known as "pear decline" that occurs also in Washington, Oregon and California, and the other is a failure of pear nursery stock to grow satisfactorily after it has been set out in the orchard.

The symptoms of pear decline in British Columbia are similar to those in Washington State described previously (9). Trees may decline in vigor and productivity slowly but progressively over a period of years until they must be removed or, more rarely, trees in a satisfactory state of vigor may die suddenly during the growing season. Associated with the unthrifty appearance of the trees is a lack of functional feeding rootlets, although the main root systems are apparently healthy.

The pear nursery stock problem is particularly puzzling. The stock grows vigorously in the nursery, and when it is dug in the fall for winter storage the root systems appear normal with a satisfactory amount of root fibre present. When the trees are lifted from the storage beds in the spring most of the fibrous roots are either lacking, or are discolored and brittle. The distal portions of larger roots also may be discolored and lack the flexibility they had in the fall. After the stock is planted in orchard sites some trees grow satisfactorily, but a high percentage remains quite unthrifty, producing only a few small leaves and little or no terminal growth. After one or two seasons with no improvement such trees are replaced, usually at the expense of the nursery company.

The two types of diseased trees display similar symptoms, namely weak growth and a conspicuous lack of functional feeding roots. These symptoms are so similar to those of other decline-type diseases caused by Phytophthora spp. in avocado (8), various conifers (2, 7), citrus (4), and grape (3), that methods by which any Phytophthora spp. present might be recovered were used in attempting to isolate a pathogen.

The results of pathogenicity tests with Phytophthora cactorum (Leb. & Cohn) Schroet. obtained from soil in orchards affected by decline, while not yet conclusive, are considered significant enough in relation to the pear decline problem to warrant this progress report.

MATERIALS AND METHODS

Many isolations were made from small roots, up to 1/8 inch in diameter in all stages of degeneration, on weakly growing bearing trees and on nursery stock. The material was treated in various ways recommended for the isolation of Phytophthora spp. prior to plating it on agar. Campbell's apple "trapping" technique (1), or Newhook's modification of it (6), were used to detect the presence of Phytophthora spp. in soil samples collected from orchards affected by pear decline and from a nursery with a history of nursery stock failure.

The pathogenicity of P. cactorum to pear seedlings was determined by dipping the roots of 30-day-old Bartlett seedlings in a zoospore suspension and planting them in sterile potting soil, and by placing inoculum in nutrient culture solutions in which seedlings were growing. Hoagland and Arnon's solution No. 1 plus trace elements (5) was used, and changed weekly.

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[1]Contribution No. 37 from the Research Station, Canada Agriculture, Summerland, British Columbia.

[2]Plant Pathologist. The technical assistance of James May is gratefully acknowledged.

EXPERIMENTAL RESULTS

Apart from Pythium ultimum, which was recovered only infrequently, no common root pathogens were obtained from any of the root isolations, nor have any been obtained yet from soil samples taken in one of the nurseries affected by the nursery stock disorder. However, P. cactorum was isolated consistently from soil in an orchard in which the majority of trees are affected by decline. In one collection of 30 samples taken from different levels in the soil around three trees, P. cactorum was recovered from 22.

The secondary roots of seedlings growing in liquid culture became infected within 6 days of inoculation. The first symptoms observed were small tan-colored lesions on the root surface. These lesions enlarged rapidly, and in a short time diseased roots became completely brown. Sporangia arose from their surface, providing a source of inoculum to infect new secondary roots that appeared at intervals and in turn became diseased. During this process of rootlet production and infection, the primary root appeared to resist invasion and there was no sign throughout most of its length that it was affected. Terminal growth ceased after the seedlings were inoculated, and no new leaves were produced during the period that infection of new roots was allowe' to proceed unchecked. However, no other secondary symptoms of root disease, such as w ing or discoloration of the foliage, appeared.

Three weeks after the seedlings were inoculated, 6 ppm soluble copper in the form of "Cheshunt compound" was added to the nutrient solution to inhibit further infections. Ten days later, at the time the photograph in Figure 1 was taken, numerous healthy-looking roots had developed, some of them arising from roots infected previously, and growth had resumed in the top.

FIGURE 1. Root of Bartlett pear seedling inoculated with P. cactorum. Note infected roots (solid arrows), and healthy roots (dotted arrows) that arose from them after copper was added to the culture solution.

The two seedlings shown in Figure 2 were photographed 30 days after the plant on the left was dipped in a zoospore suspension of P. cactorum. There were no leaves produced after the roots were inoculated, while the non-inoculated control on the right grew fairly vigorously.

DISCUSSION

The role of viruses, nitrogen fertilization, excess irrigation, new sprays for pest and disease control, root-scion combinations, the abnormal development of cells at the root-scion

FIGURE 2. The roots of the seedling on the left were dipped in a zoospore suspension before planting. The non-inoculated control is on the right.

union, and soil organisms, in the occurrence of pear decline are currently being investigated in other areas, but all of the factors which may be involved are not yet known. There is now sufficient circumstantial evidence to indicate that P. cactorum may be implicated in the development of pear decline in British Columbia and in the failure of pear nursery stock to grow satisfactorily after setting out in the orchard. The symptoms of these disorders are very similar to those of decline caused by species of Phytophthora in other tree hosts. P. cactorum has been isolated from the soil of orchards affected by decline, and symptoms characteristic of both decline and planting failures were produced in young pear seedlings when their roots were exposed to inoculum of this fungus. Further investigation will be necessary to provide convincing evidence that Phytophthora spp. are a major factor in the etiology of these diseases, but these results suggest that they may be of greater importance than has been apparent heretofore.

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BLOSSOM BLIGHT AND GREEN FRUIT ROT OF ALMOND, APRICOT AND PLUM CAUSED BY BOTRYTIS CINEREA

Joseph M. Ogawa and Harley English

Summary

Blossom blight and green fruit rot of almond and apricot incited by Botrytis cinerea, under conditions of prolonged precipitation, can reach an epidemic proportion more destructive than that caused by Sclerotinia laxa in certain areas of California. Blossom blight was most severe on almond varieties with blossoms in dense clusters (Ne Plus Ultra). B. cinerea also appears to play an important role in the blighting of Santa Rosa plum blossoms. Other stone and pome fruit blossoms inoculated were susceptible to infection. Infection of petals was enhanced by the presence of pollen grains, and penetration occurred at the junction between two epidermal cells. Green apricot fruits inoculated with a spore suspension of B. cinerea developed rot only after the fungus had established itself on dead floral parts adhering to the fruit. Styles that fail to dehisce were found to be avenues of infection for B. cinerea. Control with N-phenylmercuriethylenediamine sprays appears promising.

Blossom blight of almond (Prunus amygdalus) and apricot (Prunus armeniaca) is commonly caused by Sclerotinia laxa Aderh. & Ruhl. [Monilinia laxa (Aderh. & Ruhl.) Honey] (3). Blossom blight of apricots caused by Botrytis cinerea Pers. was photographed by Smith (5, 6). No report has been found of Botrytis causing extensive almond blossom blight. Green rot or jacket rot of apricots, as reported by various authors, has been associated with these fungi: S. sclerotiorum (Lib.) Mass., S. laxa, S. fructicola (Wint.) Rehm. [M. fructicola (Wint.) Honey] and B. cinerea (2, 7, 8). Inoculating these pathogens into green fruits has produced rot, but inoculation onto dead floral parts adhering to green fruits has not been tested. Only S. laxa has been known to cause rot of green apricot fruits in the absence of adhering shucks.

Rain during flowering and early fruit development was excessive in California in 1957 and 1958. The result was epidemic proportions of blossom blight and green rot by the complex of pathogens mentioned. Close observations of almond blossoms showed by B. cinerea was more common than S. laxa and that green rot of apricots caused by Botrytis may occur after the shuck (floral tube) has been shed. Observations and studies on development of these diseases were made in the following areas of California: 1) Sacramento Valley, 2) Delta and adjacent area, and 3) Central Coast (4).

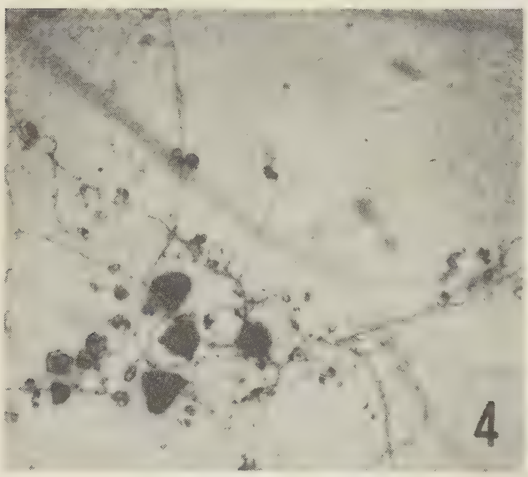
BLOSSOM BLIGHT

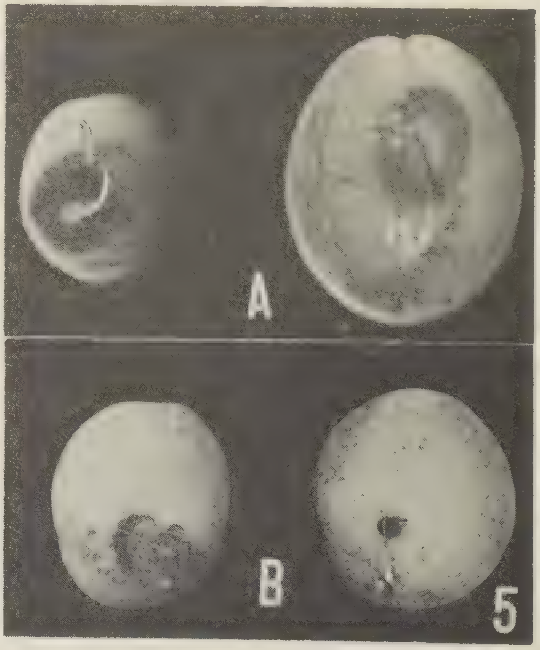
Drake and Ne Plus Ultra were the almond varieties attacked most severely. Blossom blight from B. cinerea was 10 to 40 percent in 1957 on these varieties, which have clustered blossoms (Fig. 1A). Of 165 Ne Plus Ultra blossoms from the Sacramento Valley area, 141 had necrotic areas on blossom parts. Table 1 shows the results of single isolations from each infected part.

In 1958, 20 peduncles of Ne Plus Ultra blossoms collected near Yuba City (Sacramento Valley area) resulted in the following isolations: 8, B. cinerea: 6, S. laxa; 1, S. sclerotiorum; and 5, no growth.

Isolations from 100 blighted Santa Rosa plum blossoms (Prunus salicina) from Yuba City (Sacramento Valley) in 1958 yielded 30 B. cinerea and 41 S. laxa. Isolations from 77 wilted shoots yielded B. cinerea nine times and S. laxa once. Tests for Pseudomonas syringae Van Hall from 18 similar shoots yielded 9 typical green fluorescent isolates. These results suggest that several organisms were involved in the wilting of the shoots.

Blossom inoculations of Ne Plus Ultra, Drake, and Mission (Texas) varieties of almond with spore suspensions of B. cinerea showed that blossom parts (anther, filament, stigma, petal, sepal, floral tube) are susceptible to infection when kept in a saturated atmosphere. Infections on these parts were determined by staining, clearing and observing the internal mycelia. Necrosis and aerial mycelia were visible on the spray-inoculated blossoms within 24 hours at 72° F. Figure 1B shows the type of symptoms and signs produced in saturated atmosphere, and Figure 1D shows more sporulation and less mycelial growth under field conditions. In orchards much reinfection is caused by diseased petals, which dehisce and land on





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healthy tissues. Even leaves (Fig. 2) and stems can be infected. Infection of plant parts from dehisced diseased petals has been reported (1) to play a major role in the production of disease on flax stems by this pathogen. On petals of almond, B. cinerea was found by the authors to penetrate between the cells. The appressorium of the fungus is always found at the point of

Table 1. Results of isolations from infected Ne Plus Ultra almond blossoms.

Floral parts isolated from	Number of blossoms infected (165 examined)	Blossoms from which Botrytis isolated[a] (percent)
Floral tube	120	80
Anther and filament	113	80
Petal	20	100
Stigma	14	50
Sepal	13	50
Peduncle	2	50

[a]Organisms isolated from the remaining were primarily S. laxa and S. sclerotiorum.

Table 2. Susceptibility of blossoms to Botrytis cinerea after incubation for 20 hours in saturated atmosphere at 22° C.

Host	Blossom parts				
	Petal	Anther	Filament	Stigma	Sepal
Cherry, Bing	+++[a]	+	+	+	+
Peach, Rio Oso Gem	++	-[b]	-	+	-
Hale	+++	-	-	+	-
Elberta	++	-[b]	-	+	-
Stuart	+	+	-	-	-
Nectarine, Quetta	++	+	-	+	-
Pear, Bartlett	+	+	-	+	-

[a] +++ } Petals only { whole petal necrotic + Necrosis
++ } { one-half petal necrotic - No necrosis
[b] Fungus growth, but no necrosis.

Table 3. Inoculation of 10 green apricot fruits, with and without dead blossom parts, and incubation for 6 days at 18° C in saturated atmosphere.

Spore suspension droplet inoculations of	Percent fruit infection	
	Tilton	Royal
Cheek of fruit	0	0
Style on fruit	70	100
Style attachment scar[a]	0	0
Style laid on cheek	70	100
Shuck adhering to fruit	100[b]	100[b]

[a]Styles had dehisced normally in the orchard.
[b]Tilton checks developed 75 percent infection and Royal checks 90 percent infection.

FIGURE 1. Botrytis blight of Ne Plus Ultra almond blossoms. A -- Dense cluster of blossoms highly prone to blight from infected petals. B -- Laboratory inoculations at saturated atmosphere show much aerial mycelium and little sporulation. C -- Field infection showing petal attached to floral tube and necrosis of stamens. D -- Field infection showing heavy sporulation.

FIGURE 2. Almond leaf infection resulting from contact with diseased petals.

FIGURE 3. Unopened almond bud with Botrytis sporulation.

FIGURE 4. Pollen grains stimulating Botrytis spore germination and germ tube growth on almond petal.

FIGURE 5. Green apricot fruits with Botrytis rot. A -- Infection arising from styles. B -- Small spot rots that have ceased enlarging and appear as scars on the fruit at harvest.

contact between adjacent epidermal cells. Once inside, the mycelium grows both intercellularly and intracellularly.

Unopened buds of almonds (Fig. 3) have been found with heavy sporulation of B. cinerea during the blossoming period. Botrytis-blighted open blossoms usually fall by the shuck-fall period, though a few remain attached throughout the summer. Unlike S. laxa, B. cinerea produces very little twig blight. Death of twigs was observed only when whole clusters of blossoms or blossoms and leaves were attacked.

B. cinerea spore-suspension inoculations of blossoms of various stone fruit species and one pome fruit revealed that petals, anthers, and stigmas were more prone to infection than filaments or sepals (Table 2). Petal infections were enhanced by the presence of pollen (Fig. 4), and the presence of pollen induced more rapid spore germination and germ tube growth.

GREEN FRUIT ROT OF APRICOT AND ALMOND

Isolations from 100 styles on green apricots and from 100 rotted green apricot fruit from Fairfield (delta area) yielded B. cinerea from all styles and from 95 of the fruit rots. From Hollister (central coast) isolations from 11 fruits with rot at the style end gave 8 B. cinerea, 1 Alternaria sp., and no growth from 2 fruits; isolations from 12 small decay areas on the cheek of the fruits gave 8 B. cinerea; and isolations from 12 all- or half-rotted fruits gave 6 B. cinerea. Shortly after shuck fall, 64 percent of the fruits retained the styles, and with an extended period of precipitation many of these styles were invaded by B. cinerea. The pathogen moved down the style and into the green fruit, or part of the infected style touched the fruit surface and initiated infection (Fig. 5A). These infections did not rot the whole fruit, but were walled off early (Fig. 5B), and only scars were present at harvest time. Fruit scar counts on green Royal apricot fruits showed 5 percent infection in Winters (Sacramento Valley area) and 34 percent in Fairfield (delta area).

Isolations from rotted green almonds also resulted in cultures of Botrytis along with S. sclerotiorum, which is commonly associated with this disease.

Inoculation experiments with Tilton and Royal apricots (Table 3) established that dead floral parts containing B. cinerea are essential to infection of green apricot fruit by this fungus. Inoculations with droplets of spore suspension failed to establish infections on cheeks of fruit or on the area where the style had been attached. If dead floral parts, such as styles or jackets, adhering to the green fruit are inoculated, infections of green fruit are easily established. Inoculation of the undehisced style produced infection of the green fruit at the base of the style, or, with the style bent over, infection was established at the point of contact with the fruit. These fruits were incubated 6 days at 18° C in a saturated atmosphere before final data were taken.

CONTROL

With 10 percent N-phenylmercuriethylenediamine spray applied on January 23 and February 20, 1957, at 2.5 pounds and 1.0 pound in 100 gallons, respectively, there was little or no Botrytis blossom blight on Ne Plus Ultra almond, whereas blossom blight was abundant on the unsprayed check.

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ONION SMUT CONTROL EXPERIMENTS WITH GRANULE FORMULATIONS IN GREENHOUSE AND FIELD

A. G. Newhall and J. L. Brann[1]

Summary

Greenhouse and field experiments indicate effective control of onion smut, Urocystis cepulae, can be obtained on mucklands under wet soil conditions by dribbling granular formulations into the furrow with the seed. It is not necessary to apply more than 30 pounds per acre of attaclay granules carrying no more than 4 percent of a 50 percent active fungicide containing either thiram, captan, or Phaltan.

The use of granules as carriers of insecticides for use against insects attacking seeds or seedlings is well known. The addition of fungicides to these impregnated granules is a more recent development, finding one of its applications in the control of onion maggots, Hylemia antiqua, and onion smut, Urocystis cepulae, (5). Before the advent of granules the fungicide-insecticide combinations were either dribbled into the furrow, applied to the seed (1, 2), or were blown as powders into the furrow at the time of seeding, with equipment mounted on a 3- or 4-row walking tractor described in 1951 (3, 4). One disadvantage of the dusting method is that the operator can be enveloped in an objectionable cloud of dust under some low wind conditions. This disadvantage is greatly reduced, though not completely eliminated, by the use of granules as a carrier, dropping by gravity from the end of the delivery tube only 3 inches over the furrow. The added cost of the 25 to 40 pounds of granules per acre that growers must pay each year is not vigorously objected to. The four row granule dispenser is not an expensive item since it should last for years, and ones for five, six, or more rows probably will be available soon for those who want them.

Thiram has been successfully employed in the past 15 years as a control for onion smut but it is not feasible to impregnate clay granules with it since no inexpensive solvent is known for tetramethylthiuram disulfide. While there are some objections from the formulators of granular pesticides to mechanical mixtures of powdered thiram with insecticide-impregnated granules, the fact is they do work. If growers are going to use granules for maggot control, they might as well employ a mixture that will also control smut at the same time.

Greenhouse and field experiments have shown in the past that adequate smut control can be expected from the use of 4 pounds of a 50 or 75 percent thiram fungicide distributed over 34,800 feet of row (1 acre of 15 inch rows) if deposited evenly in the furrow with the seed. In 1958-59 a greenhouse experiment was carried on to find the best concentration of dry fungicide on granules and the best rate of application per acre for safe, effective control of smut.

PROCEDURE AND RESULTS OF GREENHOUSE TRIAL

Appropriate quantities of "Arasan 75" were mixed with attaclay granules, size 30-60, to obtain four concentrations of 4, 6, 8 and 10 percent by weight. Then 75 seeds of Early Yellow Globe onion were sown in open furrows of infested muck in greenhouse flats. Quantities of each granule-fungicide mixture were scattered in the open furrows over the seed to equal rates of 23, 46, and 67 pounds per acre of row, 34,800 feet. In a duplicate sample of furrows the granules were sown first and the seeds over them, before closing the furrows. The flats were watered and held in a cool room until seedlings emerged, then in the greenhouse. Smutted seedlings were counted 25 days after sowing. There was no difference in smut between the 12 rows where seed was dropped in the furrow first and the 12 where granules were dropped in first, but emergence was a little better when granules were above the seed. There was ample smut in the checks (Table 1). The lowest concentration of fungicide (4 percent) was as effective as the highest (10 percent). Likewise, the lowest rate of application (23 pounds per acre) gave control almost as good as the two higher rates.

The degree of post emergence damping off control (Pythium) achieved with these concentrations and rates of applications is perhaps of interest as an indicator of what may be needed for other row crops. This disease on onions is seldom of importance on the mucklands but in the greenhouse it can be serious. The total percentages of emerged seedlings which damped

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Table 1. Mean percent smutted seedlings 25 days after sowing in furrows with four concentrations of fungicide-granule mixtures, each used at three rates per acre.

Percentage concentration Thiram 75	Pounds per acre 23	45	67	Mean percent smutted Treated	Checks
4	4.0	5.0	5.0	4.6	56
6	4.5	1.0	5.3	3.6	44
8	9.5	3.0	1.5	3.6	54
10	7.4	4.4	1.7	3.5	40
Mean % smut	6.4	3.4	3.4		48.5

n.s. between treatments, but treatments over checks highly significant.

off in 30 days were as follows: Checks -- 100 percent; low to high concentrations -- 11.8, 4.1, 1.6, and .3 percent respectively; low to high rates of application 7.9, 2.4, and 2.8 percent, respectively. A 6 or 8 percent concentration was a little better than a 4 percent, but no better damping off control was secured by applying more than 40 pounds per acre. Smutted plants often succumb to damping off and it's likely that many in the checks not counted as smutted actually had lesions below the ground level.

FIELD TRIAL

With this greenhouse information, three field tests were conducted in May 1959, but as practically no smut developed in two of them the data in Table 2 are from only one. The objects were to test further dosage rates under regular field conditions, to compare Captan 50 and Phaltan 50 with some available sources of thiram, and to see if granules could be used successfully to distribute concentrated formaldehyde in the furrow.

Weighed quantities of prepared granules, containing 5 percent Ethione, were previously mixed for 10 minutes with appropriate quantities of the powdered fungicides. Arasan 42-S, a slurry, was sprayed on the granules under constant agitation by men of the Research and Development Division of G. L. F. The aim was to apply all materials at 40 pounds per acre. Weighed samples were dropped into the furrows of either two or three 225-foot rows by means of two Gandy 4-row granule applicators mounted on a 5-row tractor seeder. At the ends of the rows remaining quantities were removed and reweighed. Unused outlets were plugged up and 1 percent liquid formaldehyde or Dithane solutions were dribbled into some rows for a further comparison since these are known to give excellent control of smut.

After a month replicate stand counts of the number of seedlings in 10 feet of row were made on each plot, together with the percent showing smut lesions. These data are given in Table 2, together with the pounds of granules applied per acre. From the latter figures it is obvious that is was impossible to apply the desired amount each time, as some materials would feed through the applicator faster than others at a given outlet setting. For this reason statistical analysis can not very well be applied to the data. But fortunately the results were such that a good deal of faith can be placed in most of our conclusions.

There was ample smut in the checks to prove the adequacy of the smut treatments. Granules impregnated with formaldehyde gave irregular smut control except at the higher concentration which retarded emergence and reduced the stand. All other materials and all concentrations gave reasonably good control as compared with the standard liquid treatment. With all granular materials there was no advantage in concentrations above 4 percent with either a 50 or a 75 percent active product. All materials mixed with granules gave approximately equal and satisfactory smut control under the exceedingly wet field conditions which prevailed during and after emergence. A 50 or 75 percent formulation of thiram gives as good control as a 97 percent (Tech grade) formulation. There was no marked difference in control between applications of 20 to 30 pounds and applications of 50 to 75 pounds. The 11 plots in the first category had a mean of 5.2 percent smutted plants, while 12 in the second had a mean of 5.4 percent. Thus, it apparently is not necessary to apply more than 25 or 30 pounds of granules, carrying no more than 4 percent by weight of a 50 percent active fungicide containing, thiram, captan, or Phaltan.

Table 2. Smut control with three granular concentrations of different fungicides compared with standard liquids dribbled into the furrow.

Treatment and concentration	Replication 1			Replication 2			Replication 3			Means		
	Pounds /acre	% smut	Stand in 10 feet	Pounds /acre	% smut	Stand in 10 feet	Pounds /acre	% smut	Stand in 10 feet	Pounds /acre	% smut	Stand in 10 feet
Captan 50--4%	40	3	68	40	3	38	40	1	77	40	2.3	60
--6%	20	6	68	43	9	53	35	1	32	33	5.3	51
--8%	32	2	48	34	3	48	34	10	61	33	11.3	52
Phaltan 50--4%	50	4	52	43	4.5	52	40	2.5	49.6	44	3.7	51
--6%	30	4	49	35	5.5	74	45	9.5	38	37	6.3	54
--8%	35	3	65	30	8.5	55	55	6.3	57	40	5.9	59
Arasan 75--4%	33	6.5	67	60	3	59	60	2.5	62	51	4.0	62
--6%	30	9.5	70	30	2	66	45	6	57	35	5.8	66
--8%	60	5.5	55	44	4	56	57	12.5	45	54	7.3	52
Tech Thiram--4%	30	4.5	45	75	4.5	48	57	3.5	51	54	4.1	46
--6%	36	3.5	47	65	7.5	67	36	1	23	46	4.0	46
--8%	30	9	60	35	4	50	20	1	66	28	4.6	58
Arasan 42-S--5%	27	7.5	57	37	3.5	44	40	3	43	35	4.6	48
Formald. 1g/40 lb.	65	10	56	40	25.5	43	40	15	69	48	17.0	56
Formald. 1 1/2g/40 lb.	55	6.5	26	35	5	29	36	6	27	42	5.8	27
Liq. Form. 1%	100g	2	50	100	9	39	--	--	--	100	5.5	44
Liq. Dith. 1%	100g	--	--	--	--	--	--	3	60		3	60
Check	--	41	61	--	56	25		58	58	--	51.6	48

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CONTROL OF POWDERY MILDEW OF GREENHOUSE ROSES WITH POLYBUTENES

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Abstract

Excellent control of powdery mildew of the highly susceptible variety of rose, Pink Garnet Supreme, was obtained with a series of four polybutene emulsion sprays at 7 to 10 day intervals. Karathane when followed by polybutene gave better control than a straight Karathane program and no phytotoxicity resulted. In addition, the polybutene produced a sheen and enhanced the green color of the leaves.

Small-scale tests in 1959 showed that polybutene emulsions gave promise of controlling the powdery mildews Erysiphe cichoracearum on cucumber and Sphaerotheca pannosa (Wallr.) Lév. on rose[3]. This paper reports the results of a more extensive experiment conducted later in the year on a very mildew-susceptible variety of rose in a commercial greenhouse.

MATERIALS AND METHODS

A bench 200 feet long containing four rows of Pink Garnet Supreme floribunda roses 13 to 14 inches apart in the rows was made available in a greenhouse of H. J. Mills Ltd., Richmond Hill, Ontario. The plants were first year stock planted in February 1959, with dense foliage down to the bench level and so heavily infected with powdery mildew that they would normally have been discarded. The east half of the bench was divided into unreplicated plots three plants long by four wide and treated on November 3 with 1 and 3 percent emulsions of the Indopol polybutenes[4] L-100, H-35, H-100 and H-300. Two similar plots were left unsprayed as checks. The same polybutenes were applied again on November 16, at 1 percent on all plots except the checks. It soon became apparent that H-35 was the most effective of the polybutenes, and so it alone was used at 1 percent in all plots except the checks on November 23 and December 2, as shown in Figure 1. The west half of the bench received a number of sprays of Karathane at 1/2 pound/100 Imperial gallons and 1 percent H-35 emulsion, applied separately. The arrangement of the plots is shown in Figure 2.

The polybutenes were prepared fresh as 30 percent stock emulsions containing 0.9 percent emulsifier[5], diluted as required and applied with a 2-gallon sprayer for the first application, a paint spray gun at 25 p.s.i. air pressure for the second and third sprays and with a 10-gallon motor powered sprayer for the last application. The foliage was sprayed to run-off in each case.

The development of mildew in the small polybutene plots was followed on 13 terminals selected and tagged in each plot on November 23. On December 11 an additional record was made on ten 6-inch budded terminals chosen at random in each plot. In the Karathane-polybutene plots 26 terminals were taken at random for each examination. A rating of the incidence of mildew was based on the number of leaflets on the new growth having actively sporulating spots according to the following categories: 0, clean; 1, 1-2 leaflets; 2, 3-5 leaflets; 3, 6-10 leaflets; 4, 11 or more leaflets. From the ratings a disease index was calculated for each plot:

$$\text{Disease index} = \frac{\text{sum of categories x 100}}{\text{number of terminals x 4}}$$

RESULTS

Results of the polybutene treatments on the small plots are given in Table 1.

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[3]Fisher, R. W. 1959. Polybutenes --- a promising control for powdery mildew. Plant Disease Reptr. 43: 878-879.
[4]Indopol Polybutenes, Products of the Amoco Chemical Corp., 910 South Michigan Ave., Chicago, Illinois, distributed in Canada by the R. J. Brown Co., 150 Bronoco Ave., Toronto, Ontario. Viscosities SSU at 210° F: L-100, 93.8; H-35, 375; H-100, 1070; H-300, 3000.
[5]80% Atlox G-3300, 20% Renex 680, products of Atlas Powder Co., Brantford, Ontario, Canada.

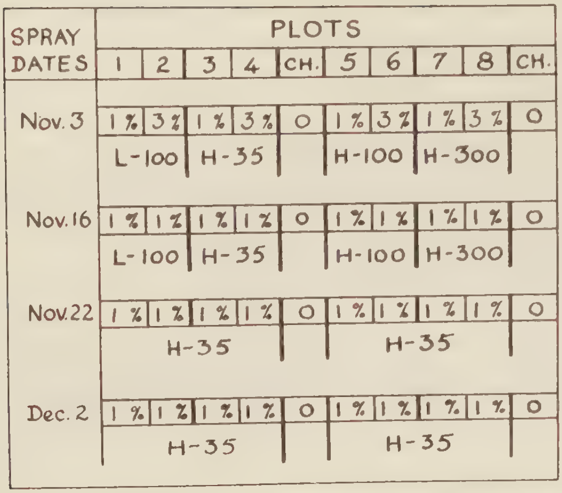

FIGURE 1. Plot arrangement and polybutene spray treatments of roses for powdery mildew on east half of a bench in a greenhouse at Richmond Hill, Ontario, 1959.

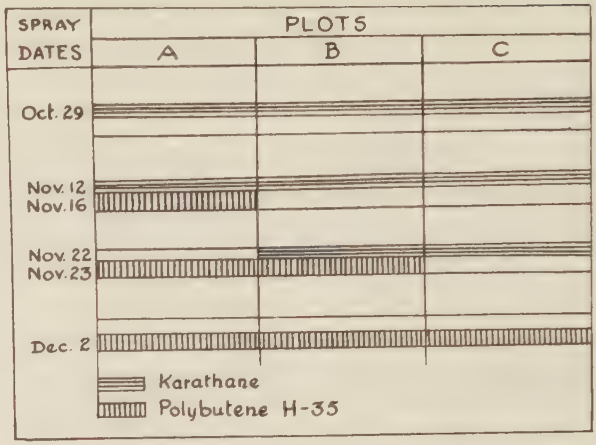

FIGURE 2. Plot arrangement and treatments of Karathane and polybutene H-35 on roses for powdery mildew on west half of a bench in a greenhouse at Richmond Hill, Ontario, 1959.

Table 1. Disease indices on greenhouse roses after polybutene treatments for control of powdery mildew, Richmond Hill, Ontario, 1959.

Plot	Nov. 23	Dec. 2	Dec. 11	Dec. 11[a]
1	52.1	59.3	8.3	20.0
2	34.6	12.5	2.3	17.5
3	36.6	11.1	0.0	7.5
4	19.2	15.6	0.0	2.75
Check 1	100.0	97.2	100.0	100.0
5	53.8	17.5	9.4	20.0
6	42.3	16.6	3.1	12.5
7	30.1	0.0	0.0	2.5
8	34.6	11.3	4.2	5.0
Check 2	75.0	89.6	68.7	100.0

[a]This additional record on December 11 was taken on ten 6-inch budded terminals selected at random in each plot.

Table 2. Indices of infection for powdery mildew on roses in plots treated with Karathane followed by 1 percent H-35 according to the plan shown in Figure 2, Richmond Hill, Ontario, 1959.

Plot	Record dates[a] and infection indices: Nov. 23	Dec. 2	Dec. 11
A	24.1	11.5	12.5
B	45.2	15.4	3.8
C	45.2	38.5	12.5
Check	100.0	100.0	100.0

[a]Records were taken before application of the polybutene sprays.

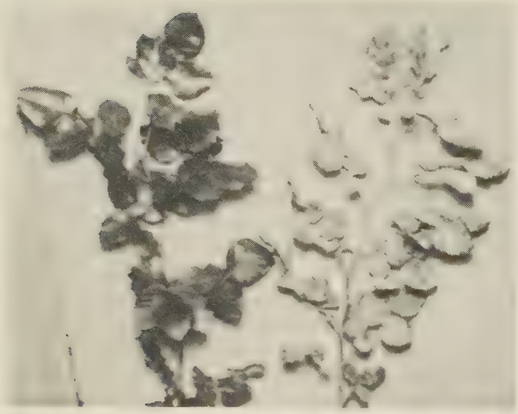

FIGURE 3. Rose stems from polybutene plot No. 4 and the adjacent untreated check plot. Note the absence of mildew spots and the sheen on the leaves of the sprayed stem to the left, and the heavy white coating of mildew on the untreated stem to the right.

A markea reduction in the incidence of mildew was evident on November 23 in all treated plots. At this time in check plot 1 all marked terminals showed severe infection with much of the foliage stunted, distorted, and completely enveloped with active mildew. Exposure of several plants in check plot 2 to spray drift was responsible for its lower incidence of disease although this was still higher than that in the treated plots.

Records on December 2 and 11 revealed a further decrease in the mildew infection following the repeated applications of polybutene. During this period some blooms were cut; no precise record was kept on their quality or market value but the grower stated that all were saleable and that he was completely satisfied with the production and quality of blooms from this bench. Without treatment the crop would have been a total loss as no saleable blooms were cut from the check plots. Figure 3 illustrates the condition of the foliage in the check plot compared with that from the H-35 plot adjacent to it.

The results in Table 2 show that Karathane afforded a good measure of mildew control, but replacing Karathane with polybutene in subsequent applications was reflected in improved control. No phytotoxicity or other difficulty was experienced in the use of polybutene as a supplement to Karathane.

The foliage in the small plots which received the accumulated polybutene from four sprays suffered a greater leaf-drop than the checks, but the extent of the drop was considered by the grower to be neither excessive nor serious. All polybutene sprays put a sheen on the leaves and made new infection spots invisible; the more viscous H-100 and H-300 left a slightly tacky residue.

DISCUSSION

Despite the lack of replication and the infection of some of the treated plots from adjacent untreated checks, the experiment clearly demonstrated the effectiveness of the polybutenes, and especially of H-35, in controlling rose mildew.

Throughout the period of the experiment an excellent source of inoculum was available in the check plots and was continually spread to new foliage. As the polybutenes were effective both in checking established infections and thus reducing the inoculum potential, and in protecting new leaves, it would seem that a complete coverage of all susceptible roses when the mildew first appears followed by protective sprays at monthly or bi-monthly intervals might keep this highly susceptible rose commercially profitable.

The tackiness produced by the more viscous H-300 and H-100 might be considered objectionable, but the residue from the most effective polybutene, H-35, was quite acceptable, at least on the variety Pink Garnet Supreme. The sheen given the leaves was regarded by the grower as rather attractive and definitely preferable to the residue left by the Karathane spray.

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A REPORT ON THE TESTING OF LOTUS SPECIES FOR RESISTANCE TO STEMPHYLIUM LEAFSPOT AND STEM CANKER

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Summary

A number of Lotus species and strains were tested for reaction to Stemphylium loti Graham. S. loti caused disease in all species of Lotus tested. Resistance was most common in varieties and strains of Lotus corniculatus. Detached leaf testing appears to be a reliable method for evaluating resistance in Lotus species to the Stemphylium leafspot disease as shown by a correlation with greenhouse testing. Field inoculations were unsuccessful.

Stemphylium leafspot and stem canker, caused by Stemphylium loti Graham (6, 7), is presently the only important foliage disease of birdsfoot trefoil (Lotus corniculatus) in New York (1, 3, 5, 8, 11). Although the disease is of potential economic significance, it was estimated that it caused only a 3 percent reduction in yield in New York during 1954, the year of most severe outbreak between 1952 and 1956 (11). The disease has been found in each of the hundred or more fields of birdsfoot trefoil inspected in New York. It seemed desirable to determine whether some sources of resistance exist that might profitably be included in plant breeding and selection programs.

MATERIALS AND METHODS

Plant materials of 43 Lotus species and 18 strains of L. corniculatus were tested under laboratory and greenhouse conditions.

Greenhouse Inoculations: All plants were grown from seed obtained from R. R. Seaney[2] except for seven species of Lotus obtained from J. S. Bubar[3]. About 30 seeds of each species and introduction of Lotus were scarified and planted in steam-sterilized soil. Three weeks later the seedlings were transplanted to steam-sterilized soil in sterilized 3-inch clay pots. Plants were clipped once, such that each plant was 6 to 8 inches tall at time of inoculation. One group of about 325 plants was tested in the spring, and another group of that size was tested in the autumn. Because the incubation chamber would accommodate only 100 pots, each group of plants was divided into thirds; several plants of each species or introduction were represented in each inoculation test.

S. loti grows well on oatmeal agar (7). Culture plates were infested with spores as suggested by R. A. Kilpatrick[4]. A wire loop containing a drop of nonsolidified agar medium was rubbed gently over a mass of spores in culture. Then it was dipped into nonsolidified agar medium in Petri dishes. Spores were distributed by stirring with the needle or by agitation of the dish. The conidia were collected from these cultures for inoculations 5 to 7 days later by pouring sterilized distilled water onto the sporulating cultures and by rubbing the entire surface with a spatula to disengage the conidia. One drop of Tween 20[5] had been added to each 100 ml of water. All inocula were strained through cheesecloth to remove mycelial fragments; spore concentrations were 6 to 8 conidia per 470X magnification of the microscope.

Spore suspensions were atomized onto foliage until run-off. The plants were incubated at approximately 75° F and 100 percent RH and continuous lights with 255 f.c. for 48 hours. Then they were placed on a greenhouse bench at about 72°.

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[5]Wetting Agent (sodium monolaurate) manufactured by the Atlas Powder Co., Chemicals Dept., Wilmington, Delaware.

Each plant was rated for disease severity 5 and 10 days after inoculation. A rating scale of 0 to 10 was used where 0 indicated no infection, 1-3 light infection, 4-6 moderate infection, 7-9 severe infection, and 10, a dead plant. Factors considered in rating were number of lesions per leaf, number of leaves infected, amount of defoliation, and number of stem lesions. Any plant with a rating of 5 or less was inoculated at least twice more to eliminate the possibility of escape and error.

Detached-Leaf Inoculations: The detached leaf method of testing forage legumes for disease resistance (10, 13, 14) was attempted here. One or two stems of each plant to be tested in the greenhouse was clipped, placed in tap water in a test tube bearing the corresponding plant number, and then taken to the laboratory. Three leaves were detached from different parts of the stem and placed on paper toweling for inoculation. A spore suspension was atomized onto the leaflets until fine droplets covered the entire upper surfaces. The leaves were then floated on a sterilized solution of 2 percent sucrose (10, 13) in sterilized Syracuse watch glasses bearing the corresponding plant number and were incubated at about 27° C. The leaves from one group of plants were kept in darkness in a controlled temperature chamber during the first 4 days, and then were placed on the laboratory bench at about 25°. Leaves of a second group of plants were kept in the laboratory at about 25° and received diffuse daylight throughout the incubation period. The 0-10 rating scale was used on the detached leaves. Considerations in using the scale were number and size of lesions per leaflet, and rapidity of sporulation on the surface of the infected leaflets.

Field Inoculations: Seedling plants of Empire and Viking birdsfoot trefoil in individual field plots were inoculated with inoculum prepared as described in an effort to insure uniformity of inoculation and development of Stemphylium leafspot disease under field conditions. The inoculum was applied with a 3-gallon pressure hand sprayer. The plants were about 3 inches tall with 3-4 trifoliate leaves at the first inoculation and about 4 inches tall with 4-6 trifoliate leaves at the second inoculation. Plants were inoculated at sunset to allow approximately a 12-hour period of high humidity and wetting of the leaves. A satisfactory epiphytotic was not induced. Temperatures ranged in the low 80's during the day and the high 50's during the night. Germination of conidia and ingress would be slow at these night temperatures and, because of sparse vegetation, the plants became dry by mid-morning after inoculation. By this time the fungus probably had not become established in the suscept tissue. Further, it was observed that seedlings were less severely diseased than older plants after inoculation in the greenhouse.

RESULTS AND DISCUSSION

Stemphylium leafspot occurred in all plants inoculated in the greenhouse and laboratory, and the causal organism S. loti was reisolated from every species. Five introductions of L. corniculatus and several other species of Lotus contained plants resistant to Stemphylium leafspot. Introductions and individual plants which exhibited resistance are identified in Tables 1 and 2. The seed sources of the species tested were commercial seed lots or increases of various collections. It is not known whether the lots tested always adequately represent the range in resistance within respective species. However, in those tested, it appears that resistance was most common in varieties and introductions of L. corniculatus. This is desirable, since crosses within L. corniculatus can easily be made, whereas, interspecific crosses have not been very successful (12). Chromosome numbers of 12, 14, 24 and 28 have been reported in Lotus (2, 4, 9).

The inocula used in different experiments could have varied in pathogenicity; this could also account for some differences in results. In each test inoculum was prepared from cultures of the fungus most recently reisolated from diseased plants, to preclude selection of inoculum that might have become less virulent as a result of repeated subculturing on oatmeal agar. The use of inoculum obtained after passing the fungus through birdsfoot trefoil could possibly result in selection of a strain more virulent than the one that was obtained originally from field-grown plants. No conclusive evidence on this was obtained.

A correlation coefficient of r= 0.841[6**] was obtained between the 5 and 10 day readings on the whole plant inoculation tests. The correlation between 5 and 10 day readings on detached leaves was r = 0.695[6**]. While disease severity readings may increase 2 or 3 units during the period between 5 and 10 days after inoculation, reliable readings can be taken at any time during this period. The r values calculated on 5 and 10 day readings for individual Lotus introductions and species were significant on 2/3 of the whole plant inoculations and for 1/2 when

6** indicates statistical significance at (P = .01) level of probability.

Table 1. Disease severity ratings of whole plants and detached leaves of Lotus species inoculated in March 1957 with spore suspensions of Stemphylium loti. Species and introductions are listed in order of resistance as judged by results of tests with whole plants.

Cornell accession number	Lotus species	Disease severity ratings[a]				Remarks[c]
		Intact plants		Detached leaves[b]		
		Mean	Range	Mean	Range	
588	L. tenuis	2.9	1-4	5.6	0-9	
554	L. corniculatus var. Viking	3.6	1-7	5.5	1-9	
696	L. creticus	3.8	1-8	6.7	4-9	
556	L. articulatus	4.3	2-8	6.9	3-9	
510	L. ornithopodioides	4.4	2-8	6.9	5-9	
698	L. pedunculatus	4.6	3-6	7.0	6-8	
661	L. grandiflorus	4.8	3-7	4.6	3-7	shot-hole
579	L. filicaulis	5.0	3-8	6.1	2-9	d
568	L. tetragonobolus var. purpureus	5.7	3-8	6.7	4-9	d
515	L. parviflorus	5.7	4-7	4.3	1-9	
598	L. uliginosus	5.9	4-8	7.6	5-9	
503	L. argophyllus var. ornithopus	6.1	2-10	6.5	3-9	
591	L. hispidus	6.3	1-8	8.1	6-9	
512	L. americanus	6.9	6-9	6.3	3-9	
516-5	L. angustissimus	6.9	4-9	4.9	0-8	
509	L. cambriensis	7.2	4-9	8.4	7-10	
506	L. maroccanus	7.4	6-9	4.0	1-8	d
663	L. salsuginosus	7.9	7-9	9.4	7-10	
608A	L. maroccanus	7.9	5-9	7.4	6-9	d
514	L. palustris	8.0	6-9	8.4	8-9	d
609	L. scoparius	8.1	7-9	7.5	7-9	f
641	L. wellerii	8.1	6-9	8.1	5-9	d
578	L. edulis	8.3	7-9	6.9	4-9	d
576	L. divaricatus	8.5	8-9	8.1	6-9	d, e
640	L. lamprocarpus	8.6	8-9	6.3	4-9	d
600	L. wrighti	8.6	7-9	8.9	7-10	d, f
639	L. arabicus	8.6*	8-9	8.0	2-9	d, f
571	L. conimbricensis					
572	L. conjugatus	--	--	--	--	rapid defoliation
607	L. denticulatus					
616	L. douglasi	These plants were susceptible but there were 6 or less plants in each species which were considered too few to report data on.				
662	L. micranthus					
669	Dorycnium hirsutum					

*Correlation coefficient (r) between ratings of whole plants and of detached leaves statistically significant at (P = 0.05).

[a]A disease severity rating scale of 0-10 was used, where 0 indicates no disease and 10 death of plant. Ratings were made 5 days after inoculation on 8-12 plants per species.

[b]Incubated in darkness for 4 days after inoculation.

[c]Symptoms which were different from Stemphylium leafspot on L. corniculatus caused by S. loti are indicated in this column..

[d]Rapid general necrosis.

[e]Severe yellowing.

[f]Dead leaves remain hanging instead of abscissing.

Table 2. Disease severity ratings of whole plants and detached leaves of Lotus species inoculated in September 1957 with spore suspensions of Stemphylium loti. Species and introductions are listed in order of resistance as judged by results of tests with whole plants.

Cornell accession number	Lotus species	Disease severity ratings[a]: Intact plants: Mean	Intact plants: Range	Detached leaves[b]: Mean	Detached leaves[b]: Range	Remarks[c]
632	L. corniculatus - Italy	0.6	0-2	6.4	2-9	
630	L. corniculatus - Argentina	1.2	0-3	6.8	3-9	
550	L. major	2.5	0-8	8.8	8-10	
699	L. corniculatus - Morocco	2.6	0-6	5.5	3-7	
530	L. corniculatus - Germany	3.0	1-6	8.5	7-9	
631	L. corniculatus - Uruguay	3.1	1-8	9.0	9	
546	L. corniculatus - Yugoslavia	3.4	0-8	8.7	7-10	
508	L. vacobraeus	3.5	1-7	9.2	8-10	
519	L. corniculatus - Canada	4.0*	1-7	8.3	8-9	
522	L. corniculatus - Denmark	4.7	1-7	8.9	8-10	
683	L. japonicus	5.3**	2-8	6.8	5-8	
629	L. corniculatus-Czechoslovakia	5.5	2-7	7.4	2-10	
V	L. corniculatus var. Viking	5.6	3-7	7.8	4-9	
539	L. corniculatus - Turkey	5.8	3-8	7.3	4-9	
EC	L. corniculatus var. Early commercial	6.1	4-8	8.3	7-9	
511	L. siliquosus	6.4	5-8	7.3	4-9	
525	L. corniculatus - France	6.8	4-8	8.7	8-10	
709	L. corniculatus - Sweden	6.9	5-8	6.5	3-9	
882B	L. corniculatus var. japonicus	7.1	6-8	6.9	5-9	
502	L. rigidus	7.3	4-9	9.3	9-10	
533	L. corniculatus - Greece	7.4	5-9	7.9	6-9	
517	L. corniculatus - Australia	7.7*	6-9	8.0	3-9	
665	L. villosus	7.7	7-9	8.1	5-9	
EM	L. corniculatus var. Empire	7.7*	6-9	9.1	6-10	
890B	L. divaricatus	7.9	7-9	9.2	7-10	d, e
880B	L. arenarius	8.1	7-9	7.5	5-10	
878B	L. purshianus	8.2	5-9	8.2	7-9	
695	L. arenarius	8.5	7-9	8.5	6-9	
888B	L. peregrinus	9.0	6-10	9.6	8-10	
886B	L. maroccanus	9.3*	8-10	9.4	7-10	d
884B	L. australis	9.6	7-10	9.9	9-10	
534	L. corniculatus - Hungary	These plants were found susceptible but there were 6 or less plants per species which was considered too few to report data on.				
587	L. stipularis					
615	L. discolor					

*Correlation coefficient (r) between ratings of whole plants and of detached leaves statistically significant at (P = 0.05).

**Correlation coefficient (r) statistically significant at (P = 0.01).

[a]A disease severity rating scale of 0-10 was used, where 0 indicates no disease and 10 death of plant. Ratings were made 5 days after inoculation.

[b]Incubated in diffuse light.

[c]Symptoms which were different from Stemphylium leafspot on L. corniculatus caused by S. loti are indicated in this column.

[d]Rapid general necrosis.

[e]Severe yellowing.

using the detached leaf method. Ten days after inoculation was found to be the upper limit for rating inoculated plants for disease severity since defoliation was then extensive. Only the 5-day readings are listed in Tables 1 and 2.

Five day readings obtained from whole-plant inoculations and from detached-leaf inoculations were compared by correlation analyses for each species and introduction. Statistically significant correlations between the two techniques were indicated in only six species (Tables 1 and 2). However, the total correlation over all species was calculated to be $r = 0.599^{6**}$. Detached leaf testing appears to be a reliable method for evaluating resistance in birdsfoot trefoil to the Stemphylium leafspot disease. Similar evidence was obtained by Ward (13), who studied the black stem disease of alfalfa. The small number of significant correlations in the individual group comparisons and the highly significant total correlation suggest that a larger number of plants of each group should be tested. Plant numbers of some species were too small to give meaningful comparisons.

Although the ratings on the diseased detached leaves were higher than the ratings on whole plants, the most resistant lines and the most susceptible ones had the same relative rank, regardless of the method used to test for resistance. As an example, all plants numbered 630, 632, and 699 were resistant and 884B, 886B, and 888B were found susceptible (Table 2) in both the detached-leaf test and the whole-plant test.

Resistance to Stemphylium loti is expressed in a number of ways over the range of Lotus species and introductions tested, as is evidenced by the deviation in types and rapidity of expression of symptoms from those normally produced on Lotus corniculatus (see under Remarks, Tables 1 and 2). It is possible that those groups which increased least in disease severity between 5 and 10 days would be of most value in breeding for field resistance in that the progression of disease development would undoubtedly be slower than that obtained under optimum conditions. Those cases where the r value between reading dates was not significant may be an indication that a different nature of resistance is operating. For instance, the pathogen, once established, may proceed slowly, ultimately causing as severe a disease as in those where the pathogen grows more rapidly.

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SUSCEPTIBILITY OF SOME SPECIES AND VARIETIES OF CITRUS AND SOME OTHER RUTACEOUS PLANTS TO THE CITRUS NEMATODE

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Summary

The following 23 Citrus species were moderately or severely infected with the citrus nematode: C. amblicarpa, C. aurantifolia, C. aurantium, C. depressa, C. excelsa, C. grandis, C. hystrix, C. ichangensis, C. jambhiri, C. limetta, C. limon, C. limonia, C. longispina, C. macrophylla, C. macroptera, C. medica, C. megaloxycarpa, C. mitis, C. paradisi, C. reticulata, C. sinensis, C. taiwanica, C. vulgaris, except C. medica var. diamante, which was infected slightly. Many varieties of grapefruit, lime, mandarin, pummelo, sour orange and sweet orange were tested.

All 12 varieties or selections of Poncirus trifoliata, except one, were highly resistant to the citrus nematode. The Frost tetraploid trifoliate orange was infected severely, while the diploid source was infected slightly.

The Texas and Uvalde citrange were infected slightly, the Carizzo, Cunningham, Morton, and Troyer moderately, and the Coleman, Rusk, and Savage severely.

Atalantia citroides was infected slightly and Cneoridium dumosum very slightly. Fortunella crassifolia (kumquat) was infected moderately and Microcitrus australasica (Australian finger lime) was infected severely.

The following plants were free of the citrus nematode: Aeglopsis chevalieri, Afraegle paniculata, Balsamocitrus dawei, Clausena lansium, Murraya paniculata, and Severinia buxifolia.

The suitability of citrus nematode resistant plants for rootstocks is considered.

The citrus nematode (Tylenchulus semipenetrans) Cobb frequently occurs on citrus and decreases the growth rate of the trees and the yield and the size of the fruit. Control of this nematode by chemicals is costly and usually involves special cultural operations. Citrus rootstocks which are non-susceptible or highly tolerant of the nematode would offer practical and effective means for control. In 1914 Cobb (4) reported that Poncirus trifoliata (trifoliate orange), grapefruit, sweet orange and sour orange were susceptible to citrus nematode in the United States. Gutierrez (6), in 1947, mentioned that grapefruit, lemon, lime, sour orange and trifoliate orange were susceptible in Argentina. The following year Du Charme (5) reported that the trifoliate orange in field plantings near Concordia, Entre Rios, Argentina was highly resistant to the citrus nematode. He also mentioned that grapefruit, lime, mandarin, Rangpur lime, Rough lemon, sweet lime, sweet orange and sour orange as stocks were susceptible in similar plantings. Certain selections or varieties of the trifoliate orange, and some other plants botanically close to citrus, were reported highly resistant or immune to the citrus nematode by Baines et al. (1) in 1948. They found that a number of citrus species were susceptible, and mentioned that the resistant plants might be useful for the breeding of nematode resistant rootstocks for citrus. Cameron et al. (3) reported in 1954 that F_1 hybrid seedlings from crosses with nematode resistant trifoliate orange and five susceptible citrus species showed marked resistance to the citrus nematode.

Many variants and varieties of citrus and other rutaceous plants botanically close to Citrus are recognized. Many of these are described by Tanaka (7), and by Swingle in chapter 4, The Citrus Industry, Webber and Batchelor (8). Information on susceptibility of 23 Citrus species, some hybrids, and some other rutaceous plants to the citrus nematode are presented herein. The merits of some of the plants for rootstocks for citrus and for resistant material for breeding nematode resistant rootstocks also are discussed.

MATERIAL AND METHODS

The roots of 8- to 30-year-old trees growing under conditions of general, natural infestations of the citrus nematode in fields were examined. A small quantity of feeder roots in the

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Table 1. Susceptibility of 23 Citrus species to the citrus nematode, Tylenchulus semipenetrans.

Citrus species[b]	Number of varieties	Number of trees	Degree of infestation[a]
Citrus amblicarpa[c]	1	6	Moderate
C. aurantifolia (lime)[d]	2	3	Severe
C. aurantium (sour orange)[e]	35	98	Mod. -Sev.
C. depressa[f]	1	5	Severe
C. excelsa[g]	1	6	do.
C. grandis (pummelo)[h]	10	30	Mod. -Sev.
C. hystrix	1	4	Severe
C. ichangensis[i]	1	10	do.
C. jambhiri[j]	4	24	do.
C. limetta[k]	2	5	do.
C. limon (lemon)[l]	5	9	do.
C. limonia[m]	4	8	do.
C. longispina[n]	1	4	Moderate
C. macrophylla[o]	1	1	Severe
C. macroptera[p]	1	5	Moderate
C. medica (citron)[q]	3	10	Sl. -Mod.
C. megaloxycarpa (C. moi)[r]	1	2	Severe
C. mitis[s]	1	5	Moderate
C. paradisi (grapefruit)[t]	15	29	Severe
C. reticulata (mandarin)[u]	12	27	Mod. -Sev.
C. sinensis (sweet orange)[v]	24	61	Mod. -Sev.
C. vulgaris[w]	1	1	Moderate
C. taiwanica[x]	1	1	Severe

[a]Infection classes; sl. (slight), mod. (moderate), and sev. (severe) designate 1 to 9, 10 to 20, and more than 20 gravid female citrus nematodes per cm of root, respectively, for the field tested roots, and 1, 1 to 3, and more than 3 for roots tested in a greenhouse. [b]The numbers in parentheses following the varietal names in the footnotes below are the accession numbers of the Citrus Experiment Station, University of California, Riverside, California. [c]Nasnaran (2485). [d]West Indian (1813), Mexican lime or Thornless (2683). [e]African (64), Algiers (2582), Argentina sour (2714, 2715, 2716), Beladi (2447), Bergamia, Bittersweet (1588, 2250), Brazilian (1110), Daidai (656), Dummitt (2541, 2549), Egypt (2436, 2538), Fawcett #363 (2717), Florida (1588), India (2576), Merritts Island (2542, 2548), myrtifolia Chinotto (2375), Naranjo Agrio (2711), Naranje de terra (2374), Oklawaha (2859), Olivelands (2717), Palermo (2442), Paraguay (660), Rehoboth (2440), Rancho Sespe (2371), Rhodesia (2444), Rubidoux (711), Seville, Spain (2441), Spanish & Italian (1589), Standard (628), Stow #15 (2190), Stow #19 (2191), Stow #20 (2192), Tel Aviv (2435), Tunis (2438, 2443), Wilson (2551), (2538, 2372). [f]Shekwasha (2448). [g]Kalpi. [h]Alamoen (2487), China (1212, 1213, 1225, 1226), C. decumana (577), Kao Panne (2349), Pink fleshed (2581), Pink shaddock (2244, 2246), Red shaddock (2547), Shaddock (2487, 2558), Siamese (640), Tau Yau (2583). [i](1215, 1219, 2584). [j]Florida Rough lemon (400), Khoubs-el-arsa or Morrocan Rough lemon (2491), Limoneira Rough lemon (123), South African Rough lemon (2325), (1459, 2422). [k]Palestine (1482), Sweet lemon (569). [l]Eureka, Hardison (1632), India (2322), Messer (1631), Rabat #1 (2491). [m]Borneo (2424), Rangpur (2318), Red or Santa Barbara (712), Sour or Red Ling Mung (2328). [n](754). [o]Alemow (2326). [p](432). [q]China (1217), Corsican (1795), Diamante (128). [r]Gajanimma (2434). [s]Calamondin (1454). [t]Blackman, Camulus Ranch, Duncan (246), Florida (343), Griffith Ranch, Hall Silver (256), McCarty (265), Pernambuco (298), Phillippines (644), Poorman orange (2381), Royal (248), Southwickii (C. celebica) (2453), Tresca (302), U.C.L.A. (1215), (343). [u]Batanges (2333), Clementine (279), Cleopatra (1461), Dancy (593), Kara (3019), King (594), Kinokuni (696), Oneco (263), Swatow (2329), Tien Chieh (2376), Tim Kat (2692), Weshart (602). [v]Bessie (245, 1693), Blackman, Bidwell Bar (1512), Camulus, Chatlos #11 (2546), Corono (2112), Dalandan (2373), Homosassa (292), Indian River (355), Italian (358, 1958), Koethen (1106), Madam Vinous (284, 1701), Olivelands, Orogold (693), Pera (2696), Phillipe #29 (2555), Rufert, St. Michael, Shamouti (cutting) (2215), Trovita, Val Rico #3 (2540), Valencia (cutting), Washington navel (cutting), Wetumka (2550). [w](760). [x]Nansho daidai (2588).

Table 2. Susceptibility of 12 non-citrus species to the citrus nematode, Tylenchulus semipenetrans.

Citrus species	Variety and identification no.[b]	No. of trees tested: In field	No. of trees tested: In pots	Degree of infestation[a]
Aeglopsis chevalieri	2878		3	None
Afraegle paniculata	3040		3	do.
Atalantia citroides	1430	1		Slight
Balsamocitrus dawei	1432	1		None
Clausena lansium	Wampee, 1460	1		do.
Cneoridium dumosum			2	Trace
Eremocitrus glauca		1		Severe
Fortunella crassifolia	Meiwa, 1471	1	3	Moderate
Microcitrus australasica	Sanguinea, 1484	2		Severe
Murraya paniculata	1637	1	3	None
Poncirus trifoliata	c	7	84	None-Sev.
Severinia buxifolia	d	9		None

[a]See Table 1, footnote a. [b]See Table 1, footnote b. [c]Argentina, Benecke, Christian, English, Fawcett-Webber (2552), Frost diploid, Frost tetraploid, Large flowered (2862), Pomeroy (1717), Rubidoux (838), Texas (2861), Towne. [d](1490, 1491, 1492, 1494, 2916).

Table 3. Susceptibility of a number of citrus hybrids to the citrus nematode, Tylenchulus semipenetrans.

Cross[b]	No. of trees tested: In field	No. of trees tested: In pots	Degree of infestation[a]
C. aurantifolia x Fortunella sp.[c]	5		Sl.-Sev.
C. grandis x C. limon[d]	4		Severe
C. grandis x C. sinensis[e]		10	do.
C. ichangensis x C. grandis[f]	4	6	Moderate
C. ichangensis x C. limon[g]	1		do.
C. ichangensis x C. reticulata[h]	2	2	Mod.-Sev.
C. limon x C. paradisi[i]	2		Severe
C. macroptera x C. reticulata[j]	3		do.
C. mitis x C. reticulata[k]		2	do.
C. reticulata x C. paradisi[l]	19	30	Mod.-Sev.
C. reticulata x C. sinensis[m]	1	12	do.
Eremocitrus glauca x C. limon[n]	2		Moderate
Fortunella japonica x C. grandis[o]	1		do.
P. trifoliata x C. aurantium[p]	3		Mod.-Sev.
P. trifoliata x C. limon[q]	2		Severe
P. trifoliata x C. paradisi[r]	3		Mod.-Sev.
P. trifoliata x C. reticulata		3	Moderate
P. trifoliata x C. sinensis[s]	20	24	Sl.-Sev.
(P. trifoliata x C. sinensis) x C. sinensis[t]	3	4	Sl.-Sev.
(P. trifoliata x C. sinensis) x Fortunella sp.[u]	5	3	Mod.-Sev.

[a]See Table 1, footnote a. [b]See Table 1, footnote b. [c](1447, 1475, 1476, 1477, 1480). [d]Cuban (1462), 1775). [e]Shaddock x St. Michael (42-1, 42-2), (1221). [f]Hsiangyuan (1215), (1219). [g](1216). [h](Yuzu (1485, 1665). [i](1481). [j]Webber's hybrid (767, 1455, 1456). [k]Calashu (Calamondin x Satsuma) (2867). [l]Clement, Frost hybrid (42-3-bs, 42-3-cs), Kerial (King x Imperial), Marlow (Willow-Leaf x Marsh), Minneola, Orlando, Sampson (399), San Jacinto (2011), Satsuma x Imperial, Seminole (2604), Sexton (2543), Siamelo (2586), Thornton (2612), Ugli (2780), Webber seedling (2746), Willial (Willow-Leaf x Imperial), Williams (2876), Willow-Leaf x Imperial. [m]Mency, Satsuma x Valencia orange, Temple (2537), Willow-Leaf x Blood orange, Willow-Leaf x Valencia orange. [n]Meyer (662). [o](2575). [p](1436, 1437, 1438). [q](1448, 1449). [r](1452, 1453). [s]Carizzo (2863), Coleman (250), Cunningham, Morton (296, 1463), Rusk (301, 1441, 1442, 1443), Savage (275), Texas (2866), Troyer (1459), Uvalde (2865). [t](1446, 1447). [u](1439, 1440, 2864).

surface foot of soil was obtained from two or three locations around each tree. Nematode resistant trees apparently were subjected repeatedly to infection by the nematode, since susceptible trees nearby in the same and in adjacent rows were infected moderately or severely in all cases.

Small seedling trees also were tested in a greenhouse. They were planted in metal pots containing a sandy loam, which contained approximately 20 citrus nematode larvae per gram of soil. Susceptible sour orange and sweet orange seedlings were used for controls in the greenhouse tests. The roots of the seedlings were removed from the soil after 8 to 12 months, and 10 to 15 grams of the small roots were cut from each seedling. Then approximately 5 grams of the feeder roots from a tree were washed carefully to remove loosely adhering soil and were placed in a flat bottom dish and covered with water. The approximate number of sessile female nematodes per centimeter of feeder root was ascertained by direct count and by scanning the roots under a dissecting microscope at 30 magnifications. Clumps of eggs and adhering soil frequently were removed carefully to expose gravid females. The degree of infestation observed on the roots of the different trees are presented in Tables 1 to 3.

DISCUSSION

In a few cases the roots of susceptible trees were infected more severely in the field than in a greenhouse. This appeared to be due to high inoculum potential and slower rate of root growth in the field rather than to differences in the susceptibility of the roots. Also, fewer nematodes occurred on the roots of nucellar seedlings of the Pomeroy and Rubidoux varieties of trifoliate orange in a greenhouse than on the roots of the parent trees in the field. This might be due to the above mentioned factors. However, Baines et al. (2) recently have shown that citrus nematode larvae obtained from resistant trifoliate orange roots are more pathogenic on nucellar seedling trifoliate orange roots than larvae obtained from (susceptible) sweet orange roots. Thus, some seedlings, which appeared highly resistant in the greenhouse tests, may later be found more susceptible under field conditions. The Argentina, Benecke, Christian, English, Texas and Towne varieties of _P. trifoliata_ were free of the citrus nematode in pot tests. These varieties have not been tested in the field. The Frost diploid _P. trifoliata_ (nucellar seedling) was infested slightly in the field, while an adjacent tetraploid tree, which was obtained from the same parent tree as the Frost diploid, was infested severely. The reason for the greater susceptibility of the tetraploid is not known, since presumably both trees contained identical chromosomes. It was the only _P. trifoliata_ tested which was infested severely. No evidence was obtained that changes in the reaction of highly susceptible trees might occur.

Selections of _P. trifoliata_, which are highly resistant to the citrus nematode, may be satisfactory as rootstocks for oranges on many soils. The resistant _P. trifoliata_ also are valuable for the breeding of resistant rootstocks since _P. trifoliata_ hybridizes readily with a number of _Citrus_ species. Recently Cameron et al. (3) have shown that a high percentage of the F_1 progeny from crosses with _P. trifoliata_ and five _Citrus_ species are highly resistant to the citrus nematode. Such nematode resistant hybrids may contain desirable characteristics of both parents.

A number of other resistant plants are of unknown or questionable value as rootstocks for citrus. It is not known whether many of these plants will hybridize with _Citrus_ species.

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OBSERVATIONS ON THE SPORULATION OF THE OAK WILT FUNGUS IN MINNESOTA[1]

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Abstract

Mycelial mats of the oak wilt fungus, Ceratocystis fagacearum (Bretz) Hunt, form in the spring of the year on red oak trees which wilted during July and August of the previous year. In the spring months of 1955 and 1956 perithecia were observed on 23 and 35 percent, respectively, of the mats and on only 2 percent of the mats that formed during the summer and fall months of 1956.

The oak wilt fungus, Ceratocystis fagacearum (Bretz) Hunt, can be spread by insects carrying spores produced on mycelial mats. To establish when the mycelial mats are formed in relation to the season of the year when the tree wilts, red oak trees, Quercus ellipsoidalis, were inoculated throughout the growing season of 1955. The trees were growing in even-aged stands within 15 miles of St. Paul, Minnesota. Naturally infected oaks of the same species were also used in this study.

The trees were inoculated by injecting a conidial suspension of the fungus into a 1/2-inch hole bored into the tree at the ground line. The trees were observed at approximately 4-day intervals from the time wilt symptoms appeared until no new mycelial mats were formed. The results are summarized in Table 1.

Table 1. Mat formation in relation to the time of year the trees wilted.

Number of trees in test	Average DBH of trees (in inches)	Date of incipient wilt symptoms	Dates of mat formation: From	To	Number of trees producing mats: 1955	1956
33	10.2	June, 1955[a]	Aug. 3	Nov. 11, 1955	4	-
33	3.7	June 4, 1955	July 12	Aug. 29, 1955	21	-
18	7.1	June 12, 1955	Aug. 18	Sept. 21, 1955	9	-
16	3.0	June 16, 1955	Aug. 5	Oct. 31, 1955	14	-
16	6.6	July, 1955[a]	Oct. 12	Nov. 11, 1955		
			May 5	June 12, 1956	6	8
5	4.5	July 14, 1955	Oct. 6	Oct. 31, 1955		
			May 1	June 2, 1956	3	1
14	6.7	Aug. 11, 1955	May 3	June 11, 1956	-	7
14	3.1	Aug. 10, 1955	Sept. 12	Oct. 31, 1955		
			May 1	June 12, 1956	4	3
11	7.0	Sept. 16, 1955	Mid-July	Aug. 10, 1956	-	8
39[b]	6.9	June 6, 1956	Sept. 27, 1956	Nov. 1, 1956		36

[a]Natural wilt; remainder of trees were artificially inoculated.
[b]No mats formed on these trees in the spring of 1957.

By inoculating oak trees at different dates it was possible to have mats forming throughout the year, except during the winter months. Mats formed in April, May, and June were on trees which wilted in July and August of the previous year. Mats produced in midsummer were on trees which wilted in September of the previous year or on smaller trees of 3 to 4 inches DBH (diameter breast high) which wilted in May, June, and July of the same year. Mats formed from September through mid-November were on trees which wilted in June and July of the same year and on small trees of 3 to 5 inches DBH which wilted in July and August.

Observations were made on the occurrence of perithecia on the mats that formed. In this study a total of 440 trees were examined; 201 trees were naturally infected, 180 trees were inoculated with both the A and B strains of the fungus and 59 trees were inoculated with only the B strain. On the inoculated trees mats formed from July through the fall of that year and also the following spring. Mats formed on naturally infected trees throughout the growing

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season, but the peak time of mat formation was in the spring and fall months, with few mats forming during the summer.

Less than 2 percent of the mats that formed during the summer and fall months of 1955 had perithecia even though 180 of those trees had been inoculated with both strains of the fungus. Of the mats that formed during April, May, and June of 1955 and 1956, 23 and 35 percent, respectively, had perithecia (Fig. 1). All of the trees involved were in an area where both strains of the fungus were known to occur naturally and where perithecia had been observed several years prior to the test.

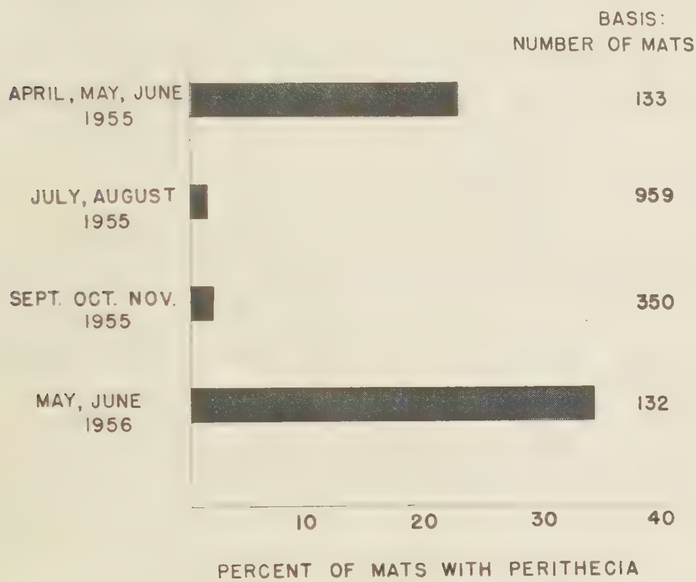

FIGURE 1. Seasonal production of perithecia.

The summer of 1955 was unusually warm. Mats that formed during the summer months would crack the bark and then would deteriorate completely within 6 days. Mats that formed in the spring and fall months did not reach a similar state of decadence until 3 weeks after cracking the bark. There were 17 days in the month of July with temperatures of 90° F or above and 10 such days in the month of August (3). Curl (2) found that high temperatures reduce both the number and germinability of conidia.

The optimum temperature for the formation of perithecia in vitro is 68° to 81° F (1). The average temperature for the month of September was 63° and for October 51.4°. Very few insects were noted on mats that formed in the fall of 1955. Low temperatures in October and absence of insects probably prevented the formation of perithecia in the fall of 1955.

Oaks wilting in July and August were the trees on which the fungus sporulated the following spring months in Minnesota. It was on these spring-formed mats that perithecia were developed most abundantly. Less than 2 percent of the mats formed in the summer and fall of 1955 had perithecia. Based on observational evidence, long distance spread apparently occurs primarily during the spring in Minnesota. The presence of a relatively large number of perithecia in the spring and greater insect populations on the mats may in part explain why overland spread occurs at this time.

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EVALUATION OF TWO SYSTEMIC INSECTICIDES APPLIED AS SEED TREATMENT FOR THE CONTROL OF MELOIDOGYNE INCOGNITA ACRITA ATTACKING COTTON

Edward L. Nigh, Jr.[1]

Abstract

Thimet and Disyston were applied to cotton seed at the rate of 1 pound toxicant per acre. The seedlings were dug 8 weeks after planting and root-knot index established.

Data revealed that neither systemic insecticide gave any indication of controlling root-knot nematode of cotton at dosages used in the investigation.

Stands were reduced slightly in the treatments, however total plants in those plots compared with non-treated checks were higher because of less "damping-off."

INTRODUCTION

The treatment of cotton seed with a chemical capable of translocation to the root zone and exhibiting nematocidal properties would be of great value.

Christie (1) reports successful treatment of rice seed with 1,3-p-chlorophenyl-5-methyl rhodamine at the rate of 1 ounce of 40 percent material per bushel. While other workers have used Systox successfully against such species as the bud nematode, *Aphelenchoides fragariae*, and the stem nematode, *Ditylenchus dipsaci*, Ford (2) is one of the few reported workers who have investigated the use of systemic insecticides for the control of nematodes.

To evaluate the systemic insecticides Thimet[2] and Disyston[3] (Bayer 19639) used as cotton seed treatment for the control of the root-knot nematode *Meloidogyne incognita acrita*, this investigation was initiated in the Mexicali Valley, Baja California, Mexico and the results are reported below.

MATERIALS AND METHODS

Mechanically delinted cotton seed of the variety Delta Pine 15 was treated with Thimet or Disyston in a mechanically rotated drum at the rate of 8 pounds of 50 percent material per 100 pounds of seed.

This seed was then planted in the desired test design (randomized block with five replications). A tractor mounted planter was used and seed was planted at the rate of 25 pounds per acre in sandy loam soil. The field had a known history of heavy root-knot nematode populations for the preceding 5 years.

To determine the effect of the materials on plant germination, damping-off, and nematode control, total plants were counted in 10 feet of row selected at random in each plot. From this area 50 plants were removed and the roots observed for root-rot injury.

Comparisons of control were made with Nemagon injected into the soil at planting date and non-treated checks.

RESULTS

Results with the systemic insecticides Thimet and Disyston used at the rate of 1 pound technical material per acre indicated no significant control of root-knot nematode (Table 1).

Damping-off was decreased and a slight germination decrease in the systemic insecticide treatments was observed. Cotyledon leaves and the first and sometimes the second pair of true leaves were noted in both Thimet and Disyston treatments to have small lesions, at first purple, later becoming white and desiccated, typical systemic insecticide symptoms on cotton in this area.

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[1] Technical Director, Agrotécnica del Valle, S. A., Mexicali, B. C., Mexico.

[2] Thimet. O,O-diethyl S-(ethyl-thio) methyl phosphorodithioate.

[3] Disyston. O,O-diethyl S-2(ethyl-thio) ethyl phosphorodithioate.

Table 1. Control of root knot with two insecticides.

Treatment	Tech. mat. /acre (in pounds)	Av. number of plants/10 feet	Percent damping-off	Root-knot index[a]
Thimet	1	112	18	2.82
Disyston	1	108	17	2.60
Nemagon	8.6	117	31	1.01
Check	-	126	27	2.78

[a] Root-knot index established by following system: 0-25 percent knotted, 1; 25-50 percent knotted, 2; 50-75 percent knotted, 3; 75-100 percent knotted, 4.

DISCUSSION

In this investigation the use of Thimet and Disyston applied as cotton seed treatments at 1 pound active material per acre respectively failed to indicate that either material was capable of killing root-knot nematode or preventing damage from the nematode.

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2. FORD, H. W. 1956. Chemicals screened for systemic effect against spreading decline disease of citrus. Plant Disease Reptr. 40: 861-865.

MEXICALI, BAJA CALIFORNIA, MEXICO

CO-OPERATIVE SEED TREATMENT TRIALS -- 1959[1]

J. E. Machacek and H. A. H. Wallace[2]

Abstract

Forty-eight seed-treatment products, 40 of them containing mercury, were tested against wheat bunt (mixed Tilletia foetida (Wallr.) Liro and T. caries (DC.) Tul.), oat smut (mixed Ustilago avenae (Pers.) Rostr. and U. kolleri (Wille), covered smut of barley (U. hordei (Pers.) Lagerh.), and seed rot of flax resulting from threshing injury. These tests were carried out under experimental plot conditions at three stations in Manitoba, and they were supplemented by greenhouse tests to show the germination of treated seed before and after storage for about 4 1/2 months in closed jars at room temperature. The results of these tests showed that 41 of the products were effective against barley smut, 36 against oat smut, 31 against wheat bunt and 12 gave satisfactory control of flax seed-rot. The effect of storage on the germination of treated seed was variable, but only one product significantly lowered germination in wheat and two others lowered it in flax. Oats and barley were not affected.

MATERIALS AND METHODS

The seed-treatment products tested in 1959 were:

Aabiton -- A liquid containing 1.5% mercury as methyl mercury benzoate. Obtained from Leytosan (Canada) Ltd., Winnipeg, Manitoba.

Agrosol -- A liquid containing 1.5% mercury as methyl mercury nitrile. Obtained from Chipman Chemicals Ltd., Winnipeg, Manitoba.

Agrox C -- A powder containing 5.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Chipman Chemicals Ltd., Winnipeg, Manitoba.

Aldmer -- A powder containing 40.0% aldrin and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Chipman Chemicals Ltd., Winnipeg, Manitoba.

Anticarie -- A powder containing 40.0% hexachlorobenzene. Obtained from H. P. Rossiger & Co., New York, N. Y.

Bunt-No-More -- A powder containing 40.0% hexachlorobenzene. Obtained from Green Cross Products, Winnipeg, Manitoba.

Canuck Liquid Mercury Concentrate -- A liquid containing 12.51% mercury as phenyl mercury acetate. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Canuck Mercury Aldrin -- A powder containing 40.0% aldrin and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Canuck Organic Mercury -- A powder containing 5.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Ceresan M -- A powder containing 3.2% mercury as ethyl mercury-p-toluene sulfonanilide. Obtained from E. I. du Pont de Nemours, Wilmington, Delaware.

Ceresan 75 -- A liquid containing 2.04% mercury as ethyl mercury 2,3-dihydroxy propyl mercaptide and ethyl mercury acetate. Obtained from E. I. du Pont de Nemours, Wilmington, Delaware.

Ceresan 100 -- A liquid containing 2.26% mercury as mixed ethyl mercury 2,3-dihydroxy propyl mercaptide and ethyl mercury acetate. Obtained from E. I. du Pont de Nemours, Wilmington, Delaware.

Ceresan 200 -- A liquid containing 4.5% mercury as mixed ethyl mercury 2,3-dihydroxy propyl mercaptide and ethyl mercury acetate. Obtained from E. I. du Pont de Nemours, Wilmington, Delaware.

[1] Contribution No. 46 from the Canada Department of Agriculture Research Station, Winnipeg, Manitoba.

[2] Principal Plant Pathologist and Associate Plant Pathologist, respectively, Plant Pathology Laboratory.

Co-op. Aldmer -- A powder containing 40.0% aldrin and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Interprovincial Co-operatives Ltd., Winnipeg, Manitoba.

Co-op. Hexa -- A powder containing 40.0% hexachlorobenzene. Obtained from Interprovincial Co-operatives Ltd., Winnipeg, Manitoba.

Co-op. Organic Mercury -- A powder containing 5.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Interprovincial Co-operatives Ltd., Winnipeg, Manitoba.

Dieldrisan -- A powder containing 20.0% dieldrin and 1.25% mercury as phenyl mercury acetate and ethyl mercury chloride. Obtained from Leytosan (Canada) Ltd., Winnipeg, Manitoba.

Gallotox -- A liquid containing 3.9% mercury as phenyl mercury acetate. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Gallotox, Triple Strength -- A liquid containing 12.51% mercury as phenyl mercury acetate. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Gallotox 50 -- A liquid containing 3.88% mercury as phenyl mercury acetate. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Half-ounce Leytosan -- A powder containing 4.5% mercury as phenyl mercury urea. Obtained from Leytosan (Canada) Ltd., Winnipeg, Manitoba.

Leytosan G.91 -- A powder containing 40.0% lindane and 1.5% mercury as phenyl mercury urea. Obtained from Leytosan (Canada) Ltd., Winnipeg, Manitoba.

Liqui-san -- A liquid containing 1.4% mercury as methyl mercury 8-hydroxyquinolinate. Obtained from Green Cross Products, Winnipeg, Manitoba.

Liqui-san Concentrate -- A liquid containing 4.2% mercury as methyl mercury 8-hydroxyquinolinate. Obtained from Green Cross Products, Winnipeg, Manitoba.

Mer-cad -- A powder containing 3.8% mercury as phenyl mercury formamide. Obtained from Stauffer Chemical Company, Omaha, Nebraska.

Mergamma C -- A powder containing 40.0% lindane and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Chipman Chemicals Ltd., Winnipeg, Manitoba.

Mer-kote -- A powder containing 4.0% mercury as phenyl mercury acetate. Obtained from Stauffer Chemical Company, Omaha, Nebraska.

Merlane H -- A powder containing 40.0% heptachlor and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Green Cross Products, Winnipeg, Manitoba.

Mer-sol 7S -- A liquid containing 4.0% mercury as phenyl mercury acetate. Obtained from Stauffer Chemical Company, Omaha, Nebraska.

Mer-sol 48 -- A liquid containing 2.82% mercury as mixed phenyl mercury acetate and ethyl mercury acetate. Obtained from Stauffer Chemical Company, Omaha, Nebraska.

Mer-sol 51 -- A liquid containing 3.53% mercury as mixed phenyl mercury acetate and ethyl mercury acetate. Obtained from Stauffer Chemical Company, Omaha, Nebraska.

No Bunt -- A powder containing 40.0% hexachlorobenzene. Obtained from Chipman Chemicals Ltd., Winnipeg, Manitoba.

Orthocide 75 -- A powder containing 75.0% captan. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Ortho LM SP (dry) -- A powder containing 3.2% mercury as methyl mercury 8-hydroxyquinolinate. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Ortho LM -- A liquid containing 1.25% mercury as methyl mercury 8-hydroxyquinolinate. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Ortho LM Concentrate -- A liquid containing 4.2% mercury as methyl mercury 8-hydroxyquinolinate. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Ortho LME -- A liquid containing 1.35% mercury as mixed ethyl mercury 8-hydroxyquinolinate and methyl mercury 8-hydroxyquinolinate. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Panogen 15 -- A liquid containing 1.5% mercury as methyl mercury dicyandiamide. Obtained from Panogen, Inc., Ringwood, Illinois.

Table 1. Summary of field results from the 1959 co-operative seed treatment trials.

Treatment	Dose (ounces/bushel)				Smut (percent)			Germination (percent)
	Wheat	Oats	Barley	Flax	Wheat	Oats	Barley	Flax
Control (dry untreated seed)	0.00	0.00	0.00	0.00	45.3	11.1	2.81	45.6
Aabiton	0.75	0.75	0.75	1.50	2.5	0.4	0.00	51.1
Agrosol	0.75	0.75	0.75	1.50	0.7	0.6	0.00	46.8
Agrox C	0.50	0.50	0.50	1.50	3.5	0.4	0.12	55.3
Aldmer	2.00	1.40	1.40	5.00	2.8	0.1	0.00	59.0
Anticarie	0.50	0.50	0.50	1.50	0.3	13.8	2.12	51.4
Bunt-No-More	0.50	0.50	0.50	1.50	0.5	9.6	1.25	47.0
Canuck Liquid Mercury Concentrate[b]	0.75	0.75	0.75	1.50	3.5	1.4	0.00	45.4
Canuck Mercury Aldrin	2.00	1.40	1.40	5.00	2.6	0.2	0.00	56.7
Canuck Organic Mercury	0.50	0.50	0.50	1.50	3.9	0.1	0.00	57.5
Ceresan M	0.50	0.50	0.50	1.50	3.9	0.0	0.00	52.8
Ceresan 75	0.75	0.75	0.75	1.50	0.8	0.0	0.12	37.5
Ceresan 100	0.50	0.50	0.50	1.50	1.7	0.4	0.00	51.8
Ceresan 200[a]	0.50	0.50	0.50	1.50	7.2	0.5	0.00	44.2
Co-op. Aldmer, Dual Purpose	2.00	1.40	1.40	5.00	4.8	0.2	0.00	59.9
Co-op. Hexa	0.50	0.50	0.50	1.50	1.3	13.3	39.2	47.9
Co-op. Organic Mercury	0.50	0.50	0.50	1.50	8.4	0.5	0.00	56.5
Dieldrisan	2.50	2.50	2.50	2.50	3.0	0.6	0.62	60.1
Gallotox	0.75	0.75	0.75	1.50	4.1	1.4	0.00	49.8
Gallotox Triple Strength[b]	0.75	0.75	0.75	1.50	3.1	2.9	0.00	46.9
Gallotox 50	0.75	0.75	0.75	1.50	2.5	0.7	0.00	49.0
Half-ounce Leytosan	0.50	0.50	0.50	1.50	2.2	0.4	0.00	54.2
Leytosan G. 91	2.00	2.00	2.00	2.00	1.7	0.4	0.00	56.5
Liqui-san	0.75	0.75	0.75	1.50	1.2	0.2	0.12	48.4
Liqui-san Concentrate[b]	0.75	0.75	0.75	1.50	8.5	0.2	0.00	49.8
Mer-cad	0.50	0.50	0.50	1.50	9.3	1.2	0.00	55.0
Mergamma C	2.00	1.40	1.40	5.00	1.1	0.1	0.00	52.2
Mer-kote	0.75	0.75	0.75	2.25	8.9	1.7	0.00	49.0
Merlane M	2.00	1.40	1.40	5.00	2.1	0.0	0.00	53.9
Mer-sol 7S	0.50	0.50	0.50	1.50	6.6	3.4	0.12	41.9
Mer-sol 48	0.75	0.75	0.75	2.25	7.3	1.4	0.12	50.3
Mer-sol 51	0.50	0.50	0.50	1.50	5.9	0.7	0.00	43.4
No Bunt	0.50	0.50	0.50	1.50	0.0	10.0	3.42	50.0
Orthocide 75	0.75	0.75	0.75	2.00	17.9	3.3	0.00	60.9
Ortho LMSP (dry)	0.50	0.50	0.50	1.50	24.8	2.5	2.00	58.8
Ortho LM	0.75	0.75	0.75	1.50	5.3	0.2	0.00	47.6
Ortho LM Concentrate[b]	0.75	0.75	0.75	1.50	1.0	1.0	0.00	49.9
Ortho LME	0.75	0.75	0.75	1.50	13.6	0.0	0.12	53.0
Panogen 15	0.75	0.75	0.75	1.50	2.3	0.0	0.25	50.4
Panogen 42[b]	0.75	0.75	0.75	1.50	0.8	0.4	0.00	48.5
Puradrin	2.00	1.40	1.40	5.00	7.5	1.1	0.12	50.2
Puraseed	0.50	0.50	0.50	1.50	15.3	2.8	0.00	57.3
San	0.50	0.50	0.50	1.50	5.6	1.1	0.00	52.4
Sanocide	0.50	0.50	0.50	1.50	1.1	11.9	2.18	48.4
Seventy-seven Triple A	2.00	1.40	1.40	5.00	3.2	0.2	0.00	53.1
Setrete	0.75	0.75	0.75	2.25	2.7	0.6	0.00	42.0
Shell Seed Dressing AM	2.00	1.40	1.40	5.00	7.8	0.3	0.00	54.8
Spergon SL	2.00	2.00	2.00	2.00	2.2	4.4	0.19	49.5
Tritisan	0.50	0.50	0.50	1.50	3.1	6.1	1.50	42.0
Significant difference (5%)					4.5	2.1	0.73	6.3

[a]Concentrate diluted before use by adding one volume of water to one volume of concentrate.
[b]Concentrate diluted before use by adding two volumes of water to one volume of concentrate.

Panogen 42 -- A liquid containing 4.2% mercury as methyl mercury dicyandiamide. Obtained from Panogen, Inc., Ringwood, Illinois.

Puradrin -- A powder containing 40.0% aldrin and 1.85% mercury as phenyl mercury formamide. Obtained from Gallowhur Chemicals Canada Ltd., Montreal, Quebec.

Puraseed -- A powder containing 3.85% mercury as phenyl mercury formamide. Obtained from Gallowhur Chemicals Canada, Ltd., Montreal, Quebec.

San -- A powder containing 5.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Green Cross Products, Winnipeg, Manitoba.

Sanocide -- A powder containing 40.0% hexachlorobenzene. Obtained from California Spray-Chemical Corporation, Maryland Heights, Missouri.

Seventy-seven Triple A -- A powder containing 40.0% aldrin, 23.0% captan, and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Seventy-seven Oil Company, Lethbridge, Alberta.

Setrete -- A liquid containing 4.0% mercury as phenyl mercury acetate. Obtained from W. A. Cleary Corporation, Belleville, Ontario.

Shell Seed Dressing AM -- A powder containing 40.0% aldrin and 2.0% mercury as mixed phenyl mercury acetate and ethyl mercury chloride. Obtained from Shell Oil Company of Canada, Toronto, Ontario.

Spergon SL -- A powder containing 97.0% chloranil (tetrachloro-para-benzoquinone). Obtained from Naugatuck Chemical Company, Elmira, Ontario.

Tritisan -- A powder containing 60.0% pentachloronitrobenzene. Obtained from Canadian Hoechst Limited, Montreal, Quebec.

The seed used for the 1959 trials was as follows:

Wheat bunt trials -- Variety Red Bobs. Seed artificially contaminated (1:200, by weight) with mixed spores of *Tilletia tritici* and *T. foetida*.

Oat smut trials -- Variety Vanguard. Seed, naturally contaminated by mixed *Ustilago avenae* and *U. kolleri*, was from a very smutty crop raised from seed inoculated by the partial-vacuum method.

Barley smut trials -- Variety Herta. Seed, naturally contaminated by *Ustilago hordei*, was also from a crop raised from artificially contaminated seed.

Flax seed-rot trials -- Variety Marine. About 50 percent of the seeds cracked during threshing.

The seed was treated by mixing predetermined quantities of fungicide and seed in closed half-gallon glass jars shaken vigorously 200 times by means of a specially built laboratory device which gave an excellent mix with fungicides in powder form and good mix with liquids. The treated seed was left in the jars for 24 hours, after which four 200-seed lots for each experiment were withdrawn from each jar for sowing in the field and two 100-seed lots for sowing in the greenhouse. The jars with the treated seed were then set aside for about 4 1/2 months after which two other 100-seed lots were withdrawn for a second sowing in the greenhouse. The field sowings provided information concerning the effectiveness of the different fungicides against smut in wheat, oats, and barley, and against seed-rot in flax, while the sowings in the greenhouse yielded data concerning the phytotoxicity of each product in the test.

EXPERIMENTAL RESULTS

The data obtained from field plots are summarized in Table 1. Forty-one of the fungicides tested were effective against covered smut of barley. Treatment with Co-op. Hexa and No Bunt seemed to increase the amount of this smut. Thirty-six treatments were effective against oat smut, but Anticarie, Bunt-No-More, Co-op. Hexa, No Bunt, and Sanocide were not, as they permitted the development of an amount of smut either equal to or greater than that found in the check plots. Thirty-one treatments were effective against wheat bunt, and in 17 of the 18 ineffective treatments the amount of bunt exceeded 5 percent. Twelve treatments were effective against seed-rot of flax.

A comparison of the results from two sowings of treated seed in the greenhouse showed that only Mergamma C reduced germination in wheat. None of the treatments reduced germination in oats or barley. Ceresan 100 and Setrete reduced germination in flax.

CANADA DEPARTMENT OF AGRICULTURE RESEARCH STATION, WINNIPEG, MANITOBA, CANADA

LEAF SCALD OF RICE, RHYNCHOSPORIUM ORYZAE, IN COSTA RICA

Lucy Hastings de Gutiérrez

For a number of years rice varieties in Costa Rica have been found occasionally infected by a fungus causing seedling and head blight and also leaf infections of a scald nature which were generally confined to the leaf tip and found on older leaves. These blights appeared to be of minor importance as compared with the serious losses caused by Helminthosporium and Piricularia, and they were seldom noted after the development of seed treating operations to control the seedling phase of the Helminthosporium disease. The leaf scald, however, has been increasing. During the past 2 years, its damage to rice leaves has been regarded with more attention and examinations of symptoms and fungus have been renewed. Since the disease and its causal organism, Rhynchosporium oryzae Hashioka & Yokogi, has not to our knowledge been previously reported on rice in the western hemisphere, it seems of interest to do so now.

Symptoms noted in Costa Rica as caused by this fungus, now known to be Rhynchosporium oryzae, are briefly reviewed as follows:

Seedling blight was characterized by a coleoptile decay with red brown infections, and root rot. Such symptoms generally came from rice farms of newly cleared forest land and under conditions of excessive moisture. Head blight seemed to involve considerable sterility and flower deformation. Sometimes a light brown discoloration of the glumes was noted. Leaf infection had an interesting appearance suggestive of a herringbone pattern which dried to a straw color, showing a faint zonation and brown margin. These infections were often little more than a yellowing of the leaf tip (Fig. 1).

The nature of these earlier symptoms, especially those of seedling and head blight, and the appearance of the fungus repeatedly isolated (1949-1952) strongly suggested a Fusarium of the F. dimerum type.

Leaf scald symptoms examined more recently are similar to those noted earlier, but more extensive. At first lenticular or diamond-shaped, the leaf spots have a striking zonate pattern formed by successive bands of dark brown bordering the light tan of the dried inside margins of the lesions. When wet with dew or rain or under conditions of high humidity, these collapsed tissues have a water-soaked appearance and heightened coloration in vivid contrast to the bright green of the otherwise healthy leaf[1]. Infection develops rapidly to involve the breadth of the leaf; and it is this rapid collapse of affected tissue which gives the appearance of scalding.

Many such infections start near the middle of the leaf, frequently causing considerable loss in leaf surface, and often early enough in the life of the plant, that is, before booting, to be of consequence.

Symptoms of leaf scald in rice resemble closely those described for Rhynchosporium on barley and found to attack other grasses by Caldwell (1) in 1937; but, apparently not until the publication of Hashioka and Ikegami (2) in 1955 was Rhynchosporium reported on rice. A study of the Japanese publication, and correspondence with Dr. Hashioka who kindly examined specimens of leaf scald from Costa Rica leave little doubt that the organism in Costa Rica is Rhynchosporium oryzae Hashioka & Yokogi. The Japanese authors, in 1955, regarded leaf scald (called Kumogatabyô in Japan) as of minor economic importance, but possibly increasing at that time. They also noted greater disease incidence with increased applications of nitrogen. It is interesting to find that in February of 1959, Makino and Hashioka (4) reported that leaf scald has become more severe in recent years in Japan.

As studied in Costa Rica, R. oryzae grows vigorously on artificial media. On PDA, growth of the fungus is rapid at approximately 22° C, with mycelium of somewhat wooly aspect, white, becoming rosy; sporulation abundant in coral pink pionnotes or scattered where agar was thin; conidia at first non-septate, then 1-septate, sickle-shaped, not pedicellate, roundly pointed at both ends, measuring approximately 12.1 x 3.4 μ. In some cultures, what appeared to be small red brown sclerotia developed after several weeks. On steamed rice, growth was more delicate; sporulation somewhat more profuse. The conidia of R. oryzae are not obliquely beaked, not cylindrical, but sickle-shaped and therefore easily distinguished from R. secalis (Oud.) J.J. Davis and R. orthosporium Caldwell, the two species known on Gramineae prior to the description of R. oryzae by Hashioka and Ikegami.

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[1] In this connection it was of interest to note from a fertilizer trial conducted in Turrialba in 1958, comparing N, P, and K at three levels, that scald infection was more prevalent among plots receiving nitrogen than among those receiving none.

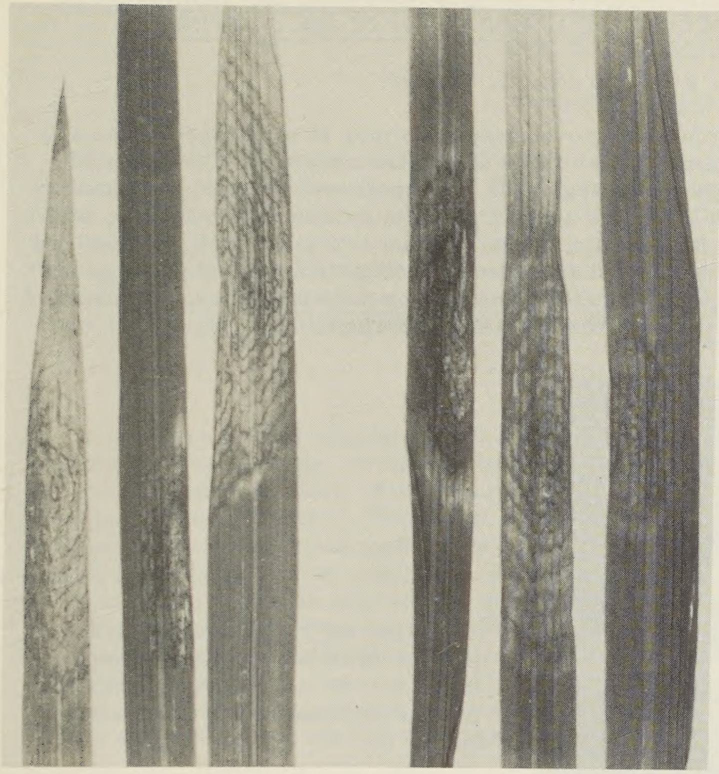

FIGURE 1. Rice leaves showing leaf scald caused by Rhynchosporium oryzae.

Inoculation experiments on cut leaves in moist chambers in Turrialba showed initial infection and subsequent development of the leaf scald to be rapid when leaves were first lightly wounded by rubbing gently with a bit of carborundum. Leaves inoculated without previous wounding also developed infection, though to a lesser extent. These results are felt to agree essentially with those of the Japanese investigators who found that without wounding infection occurs chiefly at the tip of the leaf blade, especially of the older leaves, and regarded the fungus as of rather weak pathogenicity. Yet what seems to be increasing damage by R. oryzae in Costa Rica could lead to questions regarding possible changes in pathogenicity and other relationships to infection. Caldwell's detailed study of R. secalis, causing the often serious leaf scald of barley, recognized six highly specialized physiologic races. And newly determined races have been reported more recently (3) (5). It seems very likely that a parallel situation might be shown for the leaf scald of rice.

Commonly grown commercial varieties became about equally infected in laboratory inoculation tests similar to those mentioned above. However, the response of certain other varieties in preliminary testing of this type has indicated variation in infection, and observations of varietal differences are being made in the disease nursery under conditions of natural infection.

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THE USE OF A PETROLEUM HYDRO-CARBON TORCH IN THE ASEPTIC TRANSFER OF MICROORGANISMS AND IN ROUTINE LABORATORY GLASS BLOWING

Robert P. Kahn and John L. Creech[1]

Where gas is not available, a petroleum hydro-carbon torch may be employed in lieu of a Bunsen burner or an alcohol lamp to flame culture tubes or flasks in the aseptic transfer of fungi as well as in routine laboratory glass blowing. The "Prepo Torch" (Fig. 1) has been utilized for more than 2 years for these purposes at the U. S. Plant Introduction Station, which is not currently serviced by natural or bottled gas. Culture tubes with agar slants and 500-ml and 1000-ml wide-mouth flasks have been flamed with the torch in the transfer of *Pythium ultimum* Trow, *P. butleri* Subr., *Rhizoctonia solani* Kuehn, *Cryptospora longispora* Servazzi and *Phytophthora parasitica* Dast. var. *nicotianae* (Breda de Haan) Tucker.

FIGURE 1. Petroleum hydro-carbon torch used to flame the opening of a 1000-ml wide-mouth flask in the aseptic transfer of microorganisms.

A petroleum hydro-carbon torch is more efficient and convenient than an alcohol lamp, which may also be used as a substitute for gas. However, an alcohol lamp may not provide enough heat to keep a 500-ml or larger wide-mouth flask hot enough during the transfer period. The flame from an alcohol lamp is usually not readily visible in bright sunlight, or against light backgrounds, and therefore may constitute a safety hazard. It is more convenient to heat large flasks with a torch whose flame is emitted at a 45° angle approximately 12 inches above the working surface than in the vertical flame of an alcohol lamp about 3 inches above the surface.

The hydro-carbon torch with its fine attachment is useful for routine laboratory glass blowing, such as sealing ampules, bending glass tubing, or drawing micro-pipettes. Its usefulness is obvious in laboratories not serviced by gas. Even where gas is available, the torch is usually superior to a Bunsen burner not used in conjunction with forced air or oxygen.

The torch, which is manufactured by several firms, costs approximately $6.00. The fuel consists of petroleum hydro-carbons (non-toxic and non-poisonous) and is supplied in non-refillable disposable cans costing about 60 cents.

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ESTIMATING GERMINABILITY OF SCLEROTIA

Wm. Irwin Illman

INTRODUCTION

The quantitative estimation of effect of treatment upon sclerotial bodies of fungi capable of forming them can prove a laborious, time-consuming and expensive procedure if separate cultures are made in individual tubes or plates; if several are placed in one plate there is always the danger of loss of information through overgrowth of slow-germinating sclerotia by a colony developed from one which germinates rapidly. In a recent study of the durability of sclerotia of the tomato anthracnose fungus Colletotrichum coccodes (Wallr.) Hughes [= C. phomoides (Sacc.) Chester], a simple technique was devised which overcomes these difficulties.

METHOD

Plates are poured with an agar medium satisfactory for normal development of the fungus in question (for example, potato-dextrose agar) and allowed to solidify. The agar layer is then aseptically cut into discs (4 to 5 mm diameter for assay of small sclerotia) by means of a standard "cookie-cutter." The latter instrument can be quickly assembled by brazing the 3/4-inch end of an appropriate cork-borer or similar sharpened tubing onto the end of a suitable length of a 1/4-inch brass rodding.

Individual sclerotia may now be quickly isolated to separate "cookies" on such a plate, then these sclerotium-bearing agar discs transferred to deeply poured plates of a medium such as Rose Bengal agar[1] that allows only circumscribed growth of fungi. The discs may be easily arranged in neat rows, as many as 40 or more discs to the individual plate. As growth becomes apparent (at successive observation periods) atop the PDA discs the latter may be removed and destroyed, leaving the laggards for later observation.

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[1] I am indebted to Dr. L. T. Richardson of the Pesticide Research Institute, Canada Agriculture, London, Ontario for introducing me to use of Rose Bengal agar.

POTATO LATE BLIGHT HANDBOOK AVAILABLE

POTATO BLIGHT EPIDEMICS -- Throughout the World, Agriculture Handbook No. 174, by A. E. Cox and E. C. Large and published by Agricultural Research Service, United States Department of Agriculture, is now available.

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